

Evolution-30

Intracavity-Doubled, Diode-Pumped Nd:YLF Laser

User's Manual

 **Spectra-Physics**
The Solid-State Laser Company

1335 Terra Bella Avenue
Mountain View, CA 94043

Part Number 0000-298A, Rev. B
December 2002

Preface

This manual provides information regarding the operation and maintenance of the *Evolution-30* Laser. Spectra-Physics will send a representative to install the *Evolution-30*—call us for details. The performance of the *Evolution-30* is not guaranteed unless it is installed by an authorized representative of Spectra-Physics.

The “Introduction” contains a brief description of the *Evolution-30* laser system and the accessories provided with it.

Following that section is an important chapter on safety. The *Evolution-30* is a Class IV laser and, as such, emits laser radiation which can permanently damage eyes and skin. This section contains information about these hazards and offers suggestions on how to safeguard against them. To minimize the risk of injury or expensive repairs, be sure to read this chapter—then carefully follow these instructions.

“Laser Overview” contains a short section on laser theory regarding the Nd:YLF crystal and second harmonic generation used in the *Evolution-30*. It is followed by a more detailed description of the *Evolution-30* laser system and concludes with system specifications and outline drawings.

The next few chapters describe the *Evolution-30* controls, then guide you through its installation and operation. The last part of the manual covers service and includes a replacement parts list and a list of world-wide Spectra-Physics service centers you can call if you need help.

“Service and Repair” is intended to help you guide your Spectra-Physics field service engineer to the source of any problems. *Do not attempt repairs yourself while the unit is still under warranty*; instead, report all problems to Spectra-Physics for warranty repair.

This product has been tested and found to conform to “Directive 89/336/EEC for Electromagnetic Compatibility.” Class A compliance was demonstrated for “EN 50081-2:1993 Emissions” and “EN 50082-1:1992 Immunity” as listed in the official *Journal of the European Communities*. It also meets the intent of “Directive 73/23/EEC for Low Voltage.” Class A compliance was demonstrated for “EN 61010-1:1993 Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory use” and “EN 60825-1:1992 Radiation Safety for Laser Products.” Refer to the “CE Declaration of Conformity” in Chapter 2: Laser Safety.

This product conforms to the requirements of 21 CFR 1040.10 CDRH and is compliant to Underwriters Laboratory UL1950 and is listed as ULR for recognized components. This equipment has been designed and tested to comply with the limits for a Class A digital device pursuant to Part 15 of the FCC Rules.

Every effort has been made to ensure that the information in this manual is accurate. All information in this document is subject to change without notice. Spectra-Physics makes no representation or warranty, either express or implied, with respect to this document. In no event will Spectra-Physics be liable for any direct, indirect, special, incidental or consequential damages resulting from any defects in this documentation.

Should you experience any problems with any equipment purchased from Spectra-Physics, or you are in need of technical information or support, please contact Spectra-Physics as described in Chapter 7 “Troubleshooting and Customer Service.”

Except as permitted under the United States Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a data base or retrieval system, without the prior written permission of Spectra-Physics. Under the law, copying includes translation into another language.

Finally, if you encounter any difficulty with the content or style of this manual, please let us know. The last page is a form to aid in bringing such problems to our attention.

Thank you for your purchase of Spectra-Physics instruments.

Environmental Specifications

Refer to Chapter 4, “System Installation,” for the dimensions of the major *Evolution-30* system components, and for information regarding correct placement and spacing requirements.

CE Electrical Equipment Requirements

For information regarding the equipment needed to provide the electrical service, please refer to specification EN-309, “Plug, Outlet and Socket Couplers for Industrial Uses,” listed in the official *Journal of the European Communities*.

Environmental Specifications

The environmental conditions under which the laser system will function are listed below:

Indoor use

Altitude: up to 2000 m

Temperatures: 10° C to 40° C

Maximum relative humidity: 80% non-condensing for temperatures up to 31° C.

Mains supply voltage: do not exceed $\pm 10\%$ of the nominal voltage

Insulation category: II

Pollution degree: 2

FCC Regulations

This equipment has been designed and tested to comply with the limits for a Class A digital device pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Modifications to the laser system not expressly approved by Spectra-Physics could void your right to operate the equipment.

Table of Contents

Preface	iii
Environmental Specifications	v
CE Electrical Equipment Requirements	v
Environmental Specifications	v
FCC Regulations	v
Warning Conventions	xi
Standard Units	xiii
Abbreviations	xv
Unpacking and Inspection	xvii
Unpacking Your Laser	xvii
Accessory Kit	xviii
Chapter 1: Introduction	1-1
The Laser Head	1-1
The Power Supply	1-2
The Control Computer	1-2
The Closed-Loop Chiller	1-2
Chapter 2: Laser Safety	2-1
Hazards	2-1
Optical Safety Precautions	2-2
Electrical Safety Precautions	2-3
Protective Eye Wear	2-3
CDRH Compliance	2-4
Power Switch	2-4
Keyswitch	2-4
Emission Indicators	2-4
Fault Indicator	2-5
Remote Interlock Connector	2-5
Protective Housings	2-5
Cover Safety Interlocks	2-6
Beam Safety Shutter	2-6
Beam Attenuator (Output Port)	2-6
Location of Controls	2-6
Operating Instructions	2-6
Warning Labels	2-6
CE/CDRH Drawings	2-7

CE/CDRH Labels	2-10
Label Translations	2-11
CDRH Requirements and RS-232 Control	2-12
Maintenance Required for CDRH Compliance	2-12
CE Declaration of Conformity	2-13
Sources for Additional Information	2-14
Laser Safety Standards	2-14
Equipment and Training	2-15
Chapter 3: System Operation.....	3-1
Nd:YLF Laser Material	3-1
Acousto-Optic Q-Switching	3-2
Intracavity Frequency Doubling	3-3
Laser Head Configuration	3-3
Component Descriptions	3-5
Laser Pump Chamber	3-5
AOM Q-Switches	3-5
LBO Crystal and Temperature Controller	3-5
Power Supply	3-6
Smart Analog PC Board	3-6
Diode Laser Power Supply	3-6
Q-Switch Driver	3-6
LBO Crystal Temperature Controller	3-6
The Control Computer	3-7
RS-232 Connection	3-7
Control Software	3-7
Performance Specifications.....	3-8
Chapter 4: System Installation.....	4-1
Location	4-1
Pumping a Spitfire Amplifier	4-1
Required Utilities	4-1
Preparing to Install the Power Supply	4-2
Preparing to Install the Laser Head	4-3
Preparing to Install the Control Computer	4-3
Preparing to Install the Chiller	4-4
Mechanical Specifications	4-4
Chapter 5: System Operation.....	5-1
Overview	5-1
Electrical Current Settings	5-1
Power Supply	5-2
Power Supply Front Panel	5-2
Power Supply Rear Panel	5-3
Control Software	5-4
Main Controls	5-4
SYSTEM Panel	5-5
FAULT Panel	5-6
ERROR LOG Panel	5-8
FACTORY Panel	5-8
Start-up Procedure	5-8
System Shutdown	5-9
Long Term Shutdown	5-9

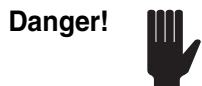
Chapter 6: Maintenance	6-1
Lasing Optimization	6-1
Cavity Mirror Adjustments	6-1
LBO Crystal Temperature Optimization	6-3
Cleaning the Optics	6-4
Routine Maintenance—Cooling Water	6-6
Chapter 7: Troubleshooting and Customer Service	7-1
Troubleshooting Guide	7-1
Symptom: Laser will not start	7-1
Symptom: Emission light comes on, but no output	7-2
Symptom: Variations in output power	7-2
Symptom: Power is below specification	7-3
Symptom: Laser does not emit Q-switched or CW output	7-3
Customer Service	7-4
Warranty	7-4
Return of the Instrument for Repair	7-4
Service Centers	7-5
Appendix A: OptiShield Algaecide	A-1
Filling the Chiller for First Time Use	A-1
Periodic Changing of Solution	A-2
MSDS Sheet for Optishield	A-3
Notes	
Report Form for Problems and Solutions	
List of Figures	
Figure 2-1: System Safety Features on the Front Panel	2-4
Figure 2-2: External Interlock Connector on the Rear Panel	2-5
Figure 2-3: CE/CDRH Radiation Control Drawing: Scientific Version	2-7
Figure 2-4: CE/CDRH Radiation Control Drawing: OEM Version	2-8
Figure 2-5: CE/CDRH Radiation Control Drawing: Power Supply	2-9
Figure 2-6: CE/CDRH Warning Labels	2-10
Figure 3-1: Acousto-Optic Modulation	3-2
Figure 3-2: Laser Head Optical Layout	3-4
Figure 4-1: Evolution-30 Scientific Laser Head Outline Drawing	4-5
Figure 4-2: Evolution-30 OEM Laser Head Outline Drawing	4-5
Figure 4-3: Evolution-30 Power Supply Outline Drawing	4-6
Figure 5-1: The Power Supply Front Panel	5-2
Figure 5-2: The Power Supply Rear Panel	5-3
Figure 5-3: Evolution-30 Control Software	5-4
Figure 5-4: The Control Software SYSTEM Panel	5-5
Figure 5-5: Control Software FAULT Panel	5-6
Figure 6-1: Access to End Mirror Adjustment Screws	6-2
List of Tables	
Table 2-1: Label Translations	2-11
Table 3-1: Specifications, Evolution-30	3-8
Table 4-1: Utility Requirement for the Evolution-30	4-2
Table 4-2: Component Weights	4-4
Table 5-1: Evolution-30 Fuse Specifications	5-3

Warning Conventions

The following warnings are used throughout this manual to draw your attention to situations or procedures that require extra attention. They warn of hazards to your health, damage to equipment, sensitive procedures, and exceptional circumstances. All messages are set apart by a thin line above and below the text as shown here.



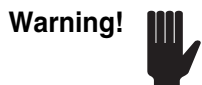
Laser radiation is present.



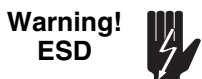
Condition or action may present a hazard to personal safety.



Condition or action may present an electrical hazard to personal safety.



Condition or action may cause damage to equipment.



Action may cause electrostatic discharge and cause damage to equipment.



Condition or action may cause poor performance or error.



Text describes exceptional circumstances or makes a special reference.



Do not touch.



Appropriate laser safety eyewear should be worn during this operation.



Refer to the manual before operating or using this device.

Standard Units

The following units, abbreviations, and prefixes are used in this Spectra-Physics manual:

Quantity	Unit	Abbreviation
mass	kilogram	kg
length	meter	m
time	second	s
frequency	hertz	Hz
force	newton	N
energy	joule	J
power	watt	W
electric current	ampere	A
electric charge	coulomb	C
electric potential	volt	V
resistance	ohm	Ω
inductance	henry	H
magnetic flux	weber	Wb
magnetic flux density	tesla	T
luminous intensity	candela	cd
temperature	Celcius	C
	Fahrenheit	F
pressure	pascal	Pa
capacitance	farad	F
angle	radian	rad

Prefixes							
tera	(10 ¹²)	T	deci	(10 ⁻¹)	d	nano	(10 ⁻⁹) n
giga	(10 ⁹)	G	centi	(10 ⁻²)	c	pico	(10 ⁻¹²) p
mega	(10 ⁶)	M	mill	(10 ⁻³)	m	femto	(10 ⁻¹⁵) f
kilo	(10 ³)	k	micro	(10 ⁻⁶)	μ	atto	(10 ⁻¹⁸) a

Abbreviations

These abbreviations may be found in this manual:

AC	alternating current
AOM	acousto-optic modulator
APM	active pulse mode locking
AR	antireflection
bi-fi	birefringent filter
CDRH	Center of Devices and Radiological Health
CW	continuous wave
DC	direct current
E/O	electro-optic
fs	femtosecond or 10^{-15} second
GTI	Gires-Toutnois Interferometer
GVD	group velocity dispersion
HR	high reflector
IR	infrared
OC	output coupler
ps	picosecond or 10^{-12} second
PZT	piezo-electric transducer
RF	radio frequency
SBR	saturable Bragg reflector
SCFH	standard cubic feet per hour
SPM	self phase modulation
TEM	transverse electromagnetic mode
Ti:sapphire	Titanium-doped Sapphire
UV	ultraviolet
λ	wavelength

Unpacking and Inspection

Unpacking Your Laser

Your *Evolution-30* laser was packed with great care, and its container was inspected prior to shipment. If any major damage was noticed at the time of receipt (holes in the containers, water damage, crushing, etc.), please notify the carrier.

Warning!



It is recommended that you wait for your Spectra-Physics representative to unpack your system. In no event should you attempt to install the laser yourself, or remove the lid sealing the laser cavity. Either action, if unauthorized, will void your warranty, and you will be charged for the repair of any damage that may result. Refer to Chapter 4, “System Installation.”

If you choose to unpack your laser system, carefully inspect the system as you do so. If any damage is evident, such as dents or scratches on the covers or broken parts, immediately notify the carrier and your Spectra-Physics sales representative.

Keep the shipping containers. If you file a damage claim, you may need them to demonstrate that the damage occurred as a result of shipping. If you need to return the system for service at a later date, the specially designed container assures adequate protection.

The *Evolution-30* system is shipped in four crates:

Laser head
Power supply
Computer and accessory kit
Chiller

Each should be carefully opened and unpacked in a clean, dry area. Inspect each component as you unpack it. To open a crate, remove the clamps around the top edge of the crate and lift off the top. (The sides are permanently fixed to the pallet.)

Warning!



Do not turn the crates upside-down or on their sides. Once out of their crates, do not turn the laser head or the chiller upside-down or on their sides. Damage to these units may result. Such damage is not covered by your warranty!

The laser head is cradled between foam blocks. Remove the laser head and its attached umbilical cord, taking care not to lift the unit using the umbilical cord or its attachment. Remove any tie-wraps or tape holding the umbilical cable in place. Put the foam blocks back in the shipping crate for storage.

Remove the laptop computer and accessory box and place them on the table. The *Evolution-30* power supply is strapped to its shipping crate. Remove the straps and carefully lift the power supply out of the crate and place it on the ground.

The last crate contains the chiller with the filter and hoses already attached. The chiller is strapped to the base of the crate. Remove the straps and carefully lift the chiller off the base of the crate. DO NOT lift the unit by the filter or its connecting fixtures.

Accessory Kit

- This *Evolution 30 User's Manual*
- Laptop computer
- One or more beam tube(s)
- 4 adjusting feet for the laser head (installed)
- A set of Allen head drivers
- Serial and power cables for the laptop computer
- Power supply power cable
- Optishield® corrosion inhibitor/algaecide
- Power supply interlock jumper and keys
- Spare chiller filter

OptiShield is a registered trademark of Opti Temp, Inc.

The *Evolution-30* is an intracavity-doubled, diode-pumped Nd:YLF laser with green output at 527 nm. The Q-switched output is pulsed at user-controlled repetition rates that are typically between 1 and 10 kHz. By using an internal removable mirror, the user can elect to have the laser beam exit the *Evolution-30* either through the front or side panel of the laser head. The system is controlled via convenient interface software installed on the laptop computer that is supplied with the system.

The *Evolution-30* system comprises four main elements:

- *Evolution-30* laser head
- Power supply
- Laptop computer and interface software
- Closed-loop chiller

The Laser Head

The laser head is a sealed aluminum chassis that contains the following components:

- Diode-pumped laser chamber
- Optical resonator assembly
- Two acousto-optic Q-switches
- Frequency-doubling crystal and temperature-controlled oven
- Safety shutter



Caution!



The *Evolution-30* was designed to provide optimum performance with minimal user intervention. Normal operation should not require the laser head cover to be opened. Removing the laser head cover without prior authorization will void the warranty.

The *Evolution-30* is available in two versions: OEM and Scientific. The aluminum chassis of the scientific version is mounted in an external housing with an emission indicator and four mounting feet that allow for beam height adjustment. The OEM version does not include this external housing, thus minimizing its footprint and allowing simpler integration of the *Evolution-30* with other instruments.

The Power Supply

The power supply contains the electronics required to drive the diode lasers, stabilize the temperature of the doubling crystal, Q-switch the laser and monitor the interlocks. The power supply connects to the laser head through a removable 3-meter long umbilical cable. The power supply contains the following components:

- Master control electronics
- Diode laser power supply
- Doubling crystal temperature controller
- Q-switch driver
- Accessory electronics

The Control Computer

The *Evolution-30* comes with a commercial laptop computer pre-loaded with LabVIEW^{TM*} software that uses an RS-232 serial interface to control and monitor the functions of the laser. Although the particular computer delivered with each laser may vary, it is specified to have:

a high-speed CPU
≥ 256 MB of RAM
≥ 10 GB hard drive
a CD-ROM drive
a floppy drive
Windows XP Home Edition^{TM**} operating system

The control software for the *Evolution-30* is pre-installed on the laptop and tested with the laser. A copy of this software is delivered on floppy disk or CD-ROM.

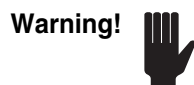
The Closed-Loop Chiller

A small closed-loop chiller is provided to dissipate waste heat. In addition it is part of the sub-system that stabilizes the wavelength of the diode lasers to ensure maximum absorption of the pump light in the gain medium. The chiller has two hoses with quick-release connectors and a pressure regulator valve to reduce the water pressure at the laser head. A chemical additive in the distilled water coolant prevents algae growth and corrosion.

The functions of the system and its components are described in detail in Chapter 3, “System Overview.”

* LabVIEW is a registered trademark of National Instruments

** Windows XP is a registered trademark of Microsoft



This user information is in compliance with Section 1040.10 of the *CDRH Laser Products Performance Standards* from the Health and Safety Act of 1968. Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.



The *Evolution-30* is a Class IV High Power Laser whose beam is a safety and fire hazard. Take precautions to prevent exposure to direct or reflected beams. Diffuse as well as specular reflections can cause severe eye or skin damage.

This safety section should be reviewed thoroughly prior to operating the *Evolution-30* laser system. Safety precautions listed in this manual should be followed carefully.

Hazards

Hazards associated with lasers generally fall into the following categories:

- Exposure to laser radiation which may result in damage to the eyes or skin
- Exposure to chemical hazards such as particulate matter or gaseous substances released as a result of laser material processing, or as by-products of the lasing process itself
- Electrical hazards generated in the laser power supply or associated circuits
- Secondary hazards such as:
 - X-radiation from faulty power supplies
 - Pressurized lamps, hoses, cylinders, etc.
 - Pressurized liquids and gasses

Optical Safety Precautions

The special nature of laser light poses safety hazards not associated with light from conventional sources. The safety precautions listed below are to be read and observed by anyone working with the laser. At all times, ensure that personnel who operate, maintain or service the laser are protected from accidental or unnecessary exposure to laser radiation exceeding the accessible emission limits listed in “Performance Standards for Laser Products,” *United States Code of Federal Regulations*, 21CFR1040.10(d).

The following safety precautions are to be observed at all times:

- Wear protective eyewear at all times; selection depends on the wavelength and intensity of the radiation, the conditions of use, and the visual function required. Protective eyewear vendors are listed in the *Laser Focus World*, *Lasers and Optronics*, and *Photonics Spectra* buyer’s guides. Consult the ANSI, ACGIH, or OSHA standards listed at the end of this section for guidance.
- Avoid wearing jewelry or other objects that may reflect or scatter the beam while using the laser.
- Work in high ambient illumination. This keeps the eye’s pupil constricted, thus reducing the possibility of eye damage.
- Never look directly into the laser beam.
- Avoid looking at the beam; even diffuse reflections are hazardous.
- Use an infrared detector to ascertain whether the laser beam is on or off before working on the laser.
- Work with the lowest beam intensity consistent with the application.
- Operate lasers only in well-marked areas with controlled access. Be sure to post appropriate warning signs, clearly visible.
- Limit access to the laser system to qualified personnel who are essential to its operation and who have been trained in the safety principles. When not in use, lasers should be shut down completely and designated off-limits to unauthorized personnel.
- Provide enclosures for beam paths whenever possible.
- Terminate the laser beam with an appropriate energy-absorbing target.
- Shield unnecessary reflections and scattered laser radiation.
- Avoid blocking the output beam or any reflections with any part of your body.
- Set up the laser so that the beam height is either well above or well below eye level.

Electrical Safety Precautions

**Danger!**

Normal operation of the *Evolution-30* should not require access to the power supply circuitry. Removing the power supply cover will expose the user to potentially lethal electrical hazards. Contact an authorized service representative before attempting to correct any problem with the power supply.

The following precautions should be observed by anyone working with potentially hazardous electrical circuitry:

- Disconnect main power lines before working on any electrical equipment when it is not necessary for the equipment to be operating.
- Do not short or ground the power supply output. Protection against possible hazards requires proper connection of the ground terminal on the power cable, and an adequate external ground. Check these connections at the time of installation, and periodically thereafter.
- Never work on electrical equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment, and who is competent to administer first aid.
- When possible, keep one hand away from the equipment to reduce the danger of current flowing through the body if a live circuit is touched accidentally.
- Always use approved, insulated tools when working on equipment.
- Special measurement techniques are required for this system. Ground references must be selected by a technician who has a complete understanding of the system operation and associated electronics.

Protective Eye Wear

It is recommended that laser-safe eye wear be worn at all times when the *Evolution-30* laser is operating. The eye wear should be attenuated to at least protect against the following wavelength ranges:

- 1047–1053 nm Covers the fundamental operation wavelength
- 523–527 nm Covers the second harmonic wavelength
- 794–810 nm Covers wavelength emitted by the diode lasers

During normal operation of the laser the operator will not be exposed directly to hazardous diode laser emission. However, removal of the mechanical housing cover will not only invalidate your warranty, but will expose you to hazardous diode laser radiation!

CDRH Compliance

The safety features listed below have been incorporated into the Scientific version of the *Evolution-30* to conform to federal performance standards as required by 21 CFR 1040.10(h)(1)(iv).

Any modification or use of the *Evolution-30* laser that changes, disables or overrides the function of the engineering controls and safety features invalidates the Class IV certification of the laser described in this manual.

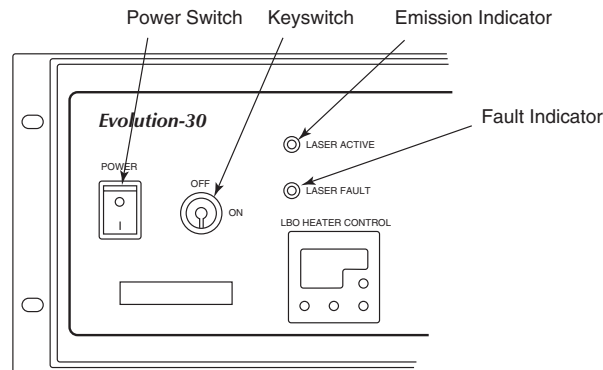


Figure 2-1: System Safety Features on the Front Panel

Power Switch

This front panel rocker switch turns on ac power to the power supply.



Line voltage to the LBO crystal heater circuit is present when the power supply is plugged in, even when the switch is in the OFF position.

Keyswitch

A separate keyswitch is provided to enable power to the laser diodes and serves as a “reset” switch to clear tripped and corrected interlocks. This key cannot be removed from the switch except in the OFF position. This prevents use of the laser by unauthorized personnel. This keyswitch does not turn off power to the power supply.

Emission Indicators

After a start command has been issued, the emission indicator on the laser head and the LASER ACTIVE lamp on the power supply turn on to warn that the laser emission is present or imminent. The following also occur:

- **Scientific *Evolution-30***

An emission indicator on the front of the laser housing turns on whenever current is supplied to the diode lasers, warning that hazardous laser radiation is present or can be accessed. Note that when this lamp is on, diode laser light is present inside the housing, even though the laser cavity may not be emitting green or infrared laser radiation (for example, when the laser is in Hold-Off mode).

- **OEM *Evolution-30***

A detachable emission indicator (supplied with the laser) can be mounted on the laser head or post-mounted in a remote location. This indicator functions in the same way as the permanent indicator on the Scientific *Evolution-30*. To comply with CDRH requirements, it must be placed in a clearly visible location no more than 10 feet (~3 m) from the *Evolution-30* output port. This indicator is required when the OEM *Evolution-30* is installed in an instrument and an indicator on the laser head is not clearly visible.

All emission indicators remain on as long as the laser is capable of lasing. They illuminate a few seconds prior to actual emission to give nearby personnel time to avoid exposure.

Fault Indicator

When the LASER FAULT indicator turns on, for safety, turn off the laser and determine the source of the fault before continuing laser use.

Remote Interlock Connector

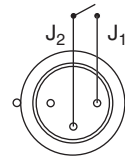


Figure 2-2: External Interlock Connector on the Rear Panel

The remote INTERLOCK connector on the back of the power supply is used to connect an external CDRH interlock. This interlock, when opened, causes the diode pump lasers to turn off. Lasing can resume only after these contacts are once again closed and the keyswitch is cycled to clear the interlock function.

For example, the interlock connector can be connected to a switch on the door to the laser room that terminates laser action automatically if anyone enters the room.

To connect the interlock switch, remove the external jumper plug and either rewire it according to the wiring diagram in Figure 2-2 or use a similar connector. Wire the external switch “normally closed,” so that when the door or safety device opens, the switch opens, turning off the diode lasers and preventing accidental exposure to laser radiation.

Protective Housings

The laser beam path is contained within the mechanical housing of the laser head until it exits at the front (or side) output port. The laser pump chamber is also contained within this housing to shield the user from stray diode laser light and to protect the diode lasers from exposure to dust and electrostatic discharge.

Cover Safety Interlocks

Interlock cover switches ensure that the *Evolution-30* laser head cannot be operated if the metal optical cavity cover is not in place and, in the Scientific version, if the external sheet metal cover is not in place.



Danger!



Do not operate the *Evolution-30* with any of its covers removed except when necessary during required service. Removing covers may expose personnel to hazardous voltages and radiation. It also increases the rate of optical surface contamination. Removing the cover that protects the optical cavity will void your warranty.

Beam Safety Shutter

A solenoid-activated safety shutter mounted in the optical cavity interrupts laser action when necessary.

By default, when the laser is turned on, either by pressing the ON button or by issuing a software command to turn on the laser, the shutter is activated (closed). The interlock fault and fail-safe mode is the closed position.

Beam Attenuator (Output Port)

The beam from the laser output port can be blocked by a manually-operated shutter. If the optional side port is used, a metal disc (supplied) can be inserted into that port to block emission.

Location of Controls

The *Evolution-30* laser is controlled via the serial interface of a remote computer. Software is provided with the laser. If the software terminates, the computer malfunctions or the serial connection is broken, the *Evolution-30* will stop lasing within 3 seconds.

Operating Instructions

Chapter 5 contains instructions for safely operating the *Evolution-30* laser.

Warning Labels

Certification and warning labels are affixed to the *Evolution-30* laser to verify compliance with 21 CFR 1040, to provide information on the wavelength and power emitted, and to warn the user against accidental exposure to laser radiation. The location and type of warning logo labels used on the *Evolution-30* laser head for the Scientific and OEM versions are shown in Figure 2-3 and Figure 2-4, respectively. Locations of the labels for the power supply cabinet are shown in Figure 2-5, and the labels themselves are shown in Figure 2-6.

Translations of the warning labels are provided in Table 2-1 for non-English speaking users. The number in parentheses in the first column corresponds to the label number in the diagram.

CE/CDRH Drawings

Labels are on page 2-10

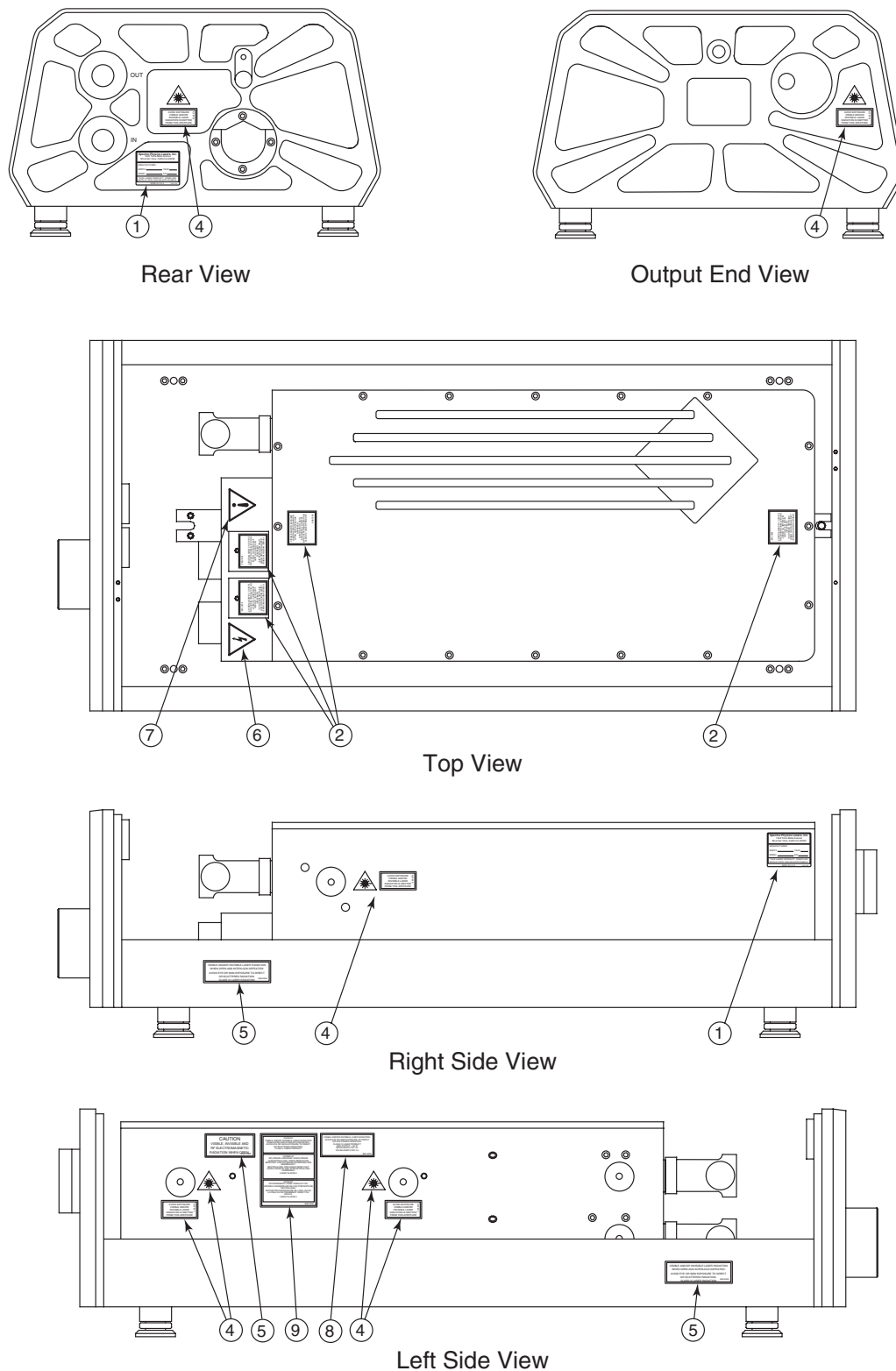


Figure 2-3: CE/CDRH Radiation Control Drawing: Scientific Version

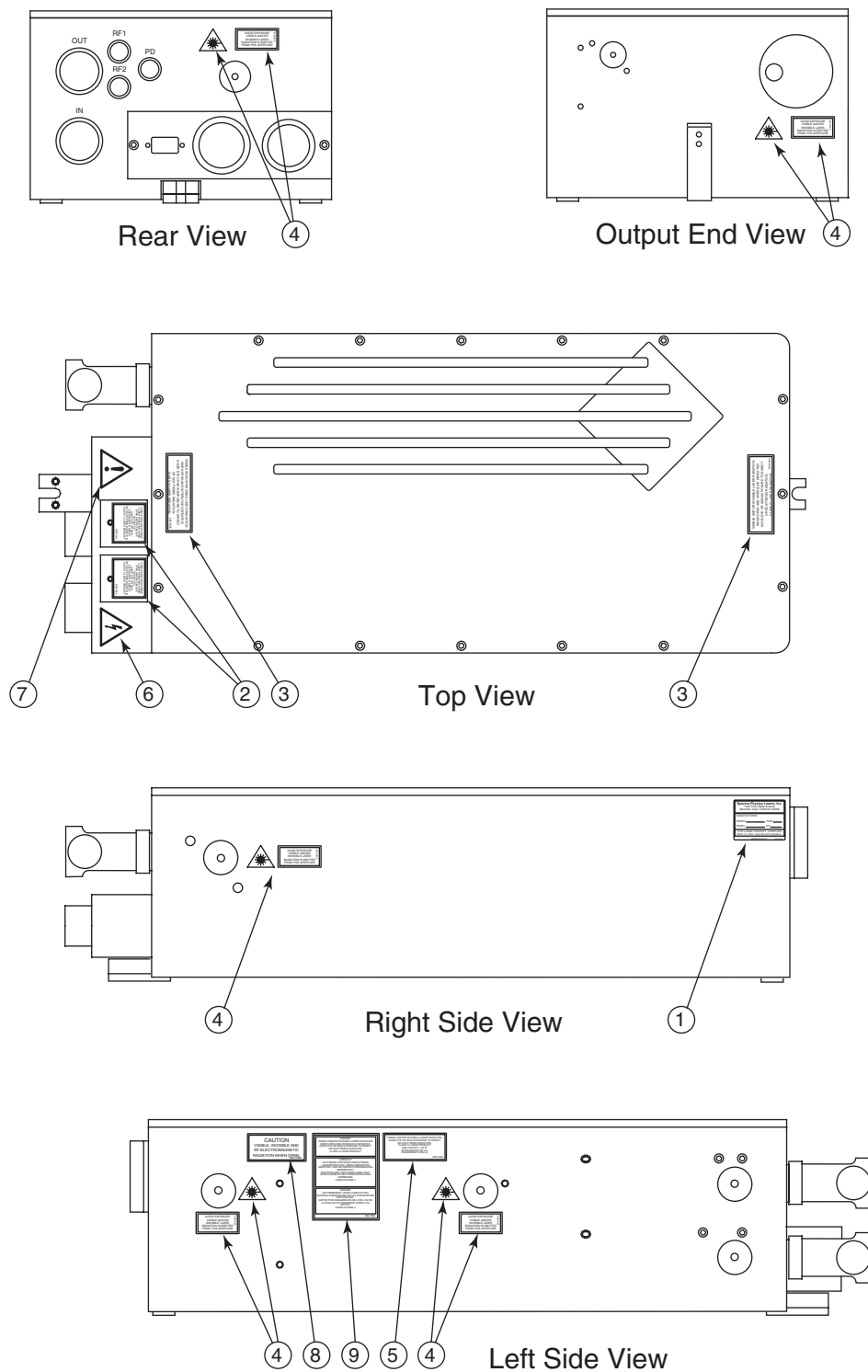
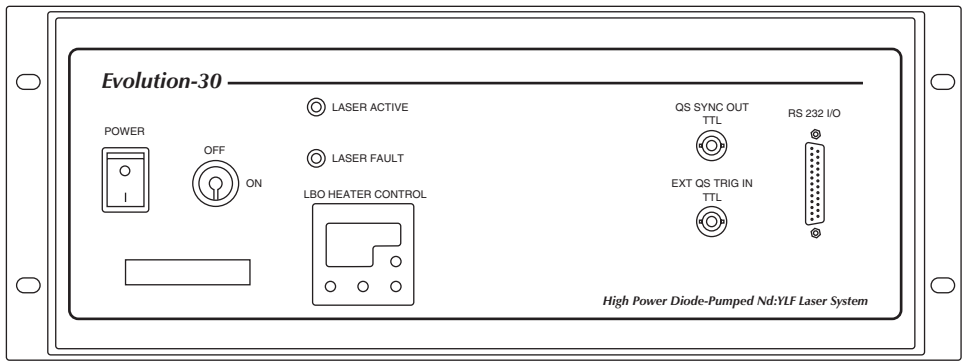
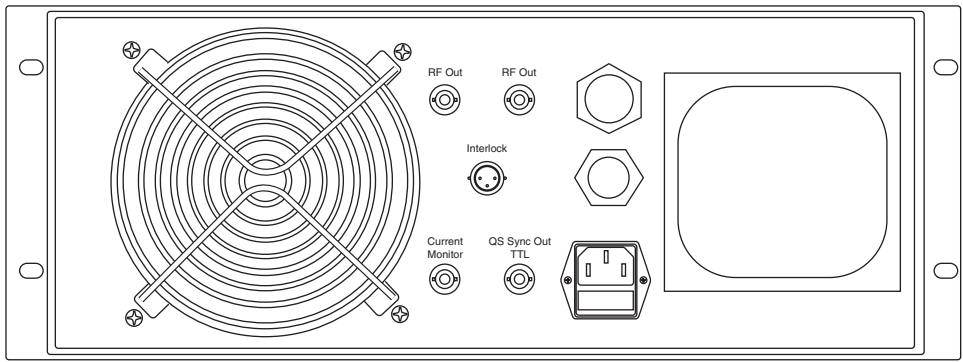


Figure 2-4: CE/CDRH Radiation Control Drawing: OEM Version



Front Panel



Rear Panel

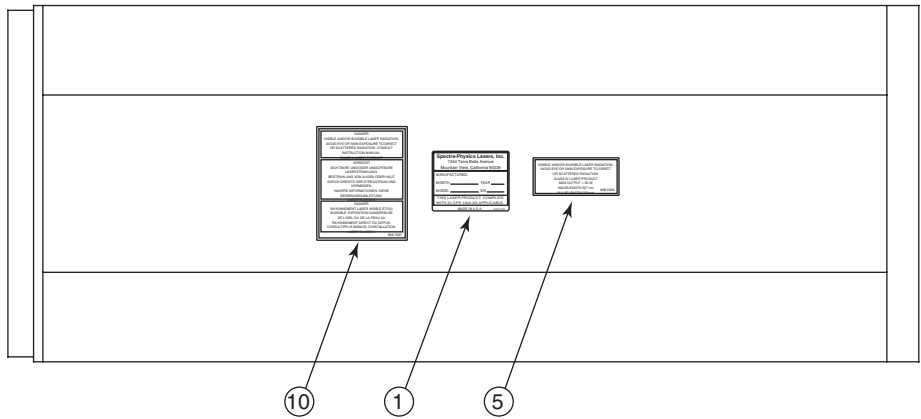


Figure 2-5: CE/CDRH Radiation Control Drawing: Power Supply

CE/CDRH Labels

Spectra-Physics Lasers, Inc. 1344 Terra Bella Avenue Mountain View, California 94039	
MANUFACTURED:	
MONTH _____	YEAR _____
MODEL _____	S/N _____
THIS LASER PRODUCT COMPLIES WITH 21 CFR 1040 AS APPLICABLE.	
MADE IN U.S.A. 0420-7840	

Identificaition/Certification
Label (1)

VISIBLE AND/OR INVISIBLE LASER RADIATION WHEN OPEN AND INTERLOCK DEFEATED! AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION. CLASS IV LASER PRODUCT 808-7255

Danger Laser Beam
Label, Laser Head (2)

VISIBLE AND/OR INVISIBLE LASER RADIATION WHEN OPEN AND INTERLOCK DEFEATED! AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION. CLASS IV LASER RADIATION 808-5326

Interlocked Cover
Label, Laser Head (3)



AVOID EXPOSURE VISIBLE AND/OR INVISIBLE LASER RADIATION IS EMITTED FROM THIS APERTURE 808-5276

Aperture Label
Laser Head (4)

VISIBLE AND/OR INVISIBLE LASER RADIATION. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION. CLASS IV LASER PRODUCT MAX OUTPUT < 50 W WAVELENGTH 527 nm PULSE LENGTH 200 µs 808-5326
--

Danger Label
Laser Output Specifications (5)



Caution Label
High Voltage (6)



Caution Label (7)

CAUTION VISIBLE, INVISIBLE AND RF ELECTROMAGNETIC RADIATION WHEN OPEN. 808-7099
--

Caution Label
RF Energy Present (8)

DANGER VISIBLE AND/OR INVISIBLE LASER RADIATION WHEN OPEN AND INTERLOCK DEFEATED. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION. CLASS 4 LASER PRODUCT
VORSICHT SICHTBARE UND/ODER UNSICHTBARE LASERSTRAHLUNG. WENN ABDECKUNG GEOFFNET UND SICHERHEITSVERRIEGLUNG ÜBERBRÜCKT. BESTRAHLUNG VON AUGEN ODER HAUT DURCH DIREKTE ODER STREUSTRAHLUNG VERMEIDEN. LASER KLASSE 4
DANGER RAYONNEMENT LASER VISIBLE ET/OU INVISIBLE DANGEREUSE EN CAS D'ORVERTURE NEUTRALISEE. EXPOSITION DANGEREUSE DE L'OEIL OU DE LA PEAU AU RAYONNEMENT DIRECT OU DIFFUS. LASER CLASSE 4 808-7098

CE Warning Label
Interlock Defeated (9)

DANGER VISIBLE AND/OR INVISIBLE LASER RADIATION. AVOID EYE OR SKIN EXPOSURE TO DIRECT OR SCATTERED RADIATION. CONSULT INSTRUCTION MANUAL. CLASS 4 LASER PRODUCT
VORSICHT SICHTBARE UND/ODER UNSICHTBARE LASERSTRAHLUNG. BESTRAHLUNG VON AUGEN ODER HAUT DURCH DIREKTE ODER STREUSTRAHLUNG VERMEIDEN. NAHERE INFORMATIONEN: SIEHE BEDIENUNGSANLEITUNG. LASER KLASSE 4
DANGER RAYONNEMENT LASER VISIBLE ET/OU INVISIBLE. EXPOSITION DANGEREUSE DE L'OEIL OU DE LA PEAU AU RAYONNEMENT DIRECT OU DIFFUS. CONSULTER LE MANUEL D'INSTALLATION. LASER CLASSE 4 808-7097

CE Warning Label
Power Supply (10)

Figure 2-6: CE/CDRH Warning Labels

Label Translations

For safety, the following translations are provided for non-English speaking personnel. The number in parenthesis in the first column corresponds to the label number listed on the previous page.

Table 2-1: Label Translations

Label #	French	German	Spanish	Dutch
Danger Label (2) and Interlocked Cover Label (3)	Rayonnement Laser Visible et/ou Invisible en Cas D'Ouverture et lorsque la sécurité est neutralisée; exposition dangereuse de l'oeil ou de la peau au rayonnement direct ou diffus. Laser de Classe 4.	Sichtbare und/oder unsichtbare Laserstrahlung wenn geöffnet und Sicherheitsverriegelung überbrückt. Bestrahlung von Augen oder Haut durch direkt oder Streustrahlung vermeiden. Laser Klasse 4.	Al abrir y retirar el dispositivo de seguridad exist radiación laser visible y invisible; evite que los ojos o la piel queden expuestos tanto a la radiación directa como a la dispersa. Producto laser clase 4.	Zichtbare en onzichtbare laserstraling! Vermijd blootstelling van oog of huid aan directe straling of terugkaatsingen daarvan! Klasse 4 laser produkt.
Aperture Label (4)	Exposition Dangereuse! Rayonnement visible et/ou invisible est émis par cette ouverture	Austritt von sichtbarer und unsichtbarer Laserstrahlung. Bestrahlung vermeiden!	Por esta abertura se emite radiación laser visible e invisible; evite la exposición	Vanuit dit apertuur wordt zichtbare en onzichtbare laserstraling geëmitteerd! Vermijd blootstelling!
Danger Label Output Specifications (5)	Visible et/ou invisible radiation laser. Evitez l'exposition de la peau de vos yeux et de votre peau au rayonnement direct ou diffus. Appareil laser de classe IV. Puissance max.: < 50 W, Longueur d'onde: 527 nm, Largeur de pulse: < 200 µs.	Sichtbare und/oder unsichtbare Laserstrahlung! Augen- oder Hautkontakt mit direkter oder Streustrahlung vermeiden! Product der Laserklasse IV, Max. Ausgangsleistung: < 50 W, Wellenlänge: 527 nm, Pulsdauer: < 200 µs.	Radiación laser visible y/o invisible. Evitar la exposición directa o dispersada de radiación con los ojos o piel. Clase IV Producto Laser, Máxima Salida: < 50 W, Longitud de onda: 527 nm, Logitud de pulso: < 200 µs.	Zichtbare en/of onzichtbare laserstraling. Vermijd oog-en huidcontact van de directe en indirecte Straling. Klasse IV laserapparatuur. Maximaal uitgangsvermogen: < 50 W, Golflengte: 527 nm, Pulsduur 200 µs.
Caution Label RF Energy Present (8)	Attention. Radiation laser visible et invisible rayonnement RF, capot ouvert.	Vorsicht! Austritt von sichtbarer, unsichtbarer und Hochfrequenzstrahlung, wenn geöffnet.	Precaucion. Radiación magnetica visible, invisible y de radio frecuencia si abierto.	Opgepast zichtbare, onzichtbare en hoogfrequent elektromagnetische Straling bij het openen.

CDRH Requirements and RS-232 Control

The *Evolution-30* and its power supply comply with CDRH safety standards that apply to operating the laser through an RS232 interface. A software indicator shows when laser radiation is present or can be accessed.

Maintenance Required for CDRH Compliance

This section lists the maintenance required to keep this laser product in compliance with CDRH regulations.

This laser product complies with Title 21 of the *United States Code of Federal Regulations*, Chapter 1, Sub-chapter J, Parts 1040.10 and 1040.11, as applicable. To maintain compliance, verify the operation of all features listed below, either annually or whenever the product has been subjected to adverse environmental conditions (e.g., fire, flood, mechanical shock, spilled solvents). This maintenance is to be performed as outlined below.

- Verify that removing the laser cover closes the intracavity shutter.
- Verify that all the warning labels listed in Figure 2-3, Figure 2-4 and Figure 2-5 are present and firmly affixed in the correct locations.
- Verify that removing the INTERLOCK connector on the rear panel of the power supply prevents operation of the laser.
- Verify that the time delay between illumination of the emission indicator and start of laser emission gives enough warning to allow personnel to avoid exposure to the radiation.
- Verify that the internal beam attenuator (shutter):
 - a. operates properly when the laser is turned off from the computer controller,
 - b. closes when the keyswitch is turned off, and
 - c. blocks access to laser radiation.

CE Declaration of Conformity

We,

Spectra-Physics
1330 Terra Bella Avenue
Mountain View, CA. 94043
United States of America

declare under our sole responsibility that the:

**Evolution-30 diode-pumped, intracavit-doubled Nd:YLF laser system
with power supply, and compliant pc-based controller, and Neslab
or Lytron chiller**

manufactured after July 1999.

to which this declaration relates is in conformance with:

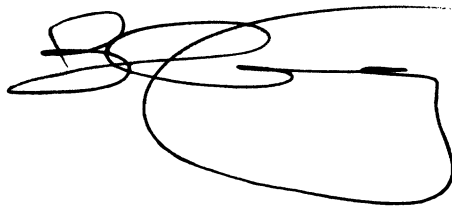
the provisions of Directive 73/23/EEC governing product safety using the
following standards:

EN 60950: 1997
EN 61010-1: 2001
EN 60825-1: 1994

the provisions of Directive 89/336/EEC governing electromagnetic compati-
bility using the following standards:

EN 61326-1 w/A1: 1997

I, the undersigned, hereby declare that the equipment specified above con-
forms to the above Directives and Standards.

A handwritten signature in black ink, appearing to read 'Bruce Craig', with a large, sweeping loop at the end.

Bruce Craig
Vice President and General Manager
Spectra-Physics
Laser Group
April 5, 2002
Mountain View, California
USA

Sources for Additional Information

The following are some sources for additional information on laser safety standards, safety equipment, and training.

Laser Safety Standards

Safe Use of Lasers (Z136.1: 1993)

American National Standards Institute (ANSI)

11 West 42nd Street

New York, NY 10036

Tel: (212) 642-4900

Occupational Safety and Health Administration (Publication 8.1-7)

U. S. Department of Labor

200 Constitution Avenue N. W., Room N3647

Washington, DC 20210

Tel: (202) 693-1999

A Guide for Control of Laser Hazards, 4th Edition, Publication #0165

American Conference of Governmental and

Industrial Hygienists (ACGIH)

1330 Kemper Meadow Drive

Cincinnati, OH 45240

Tel: (513) 742-2020

Internet: www.acgih.org/home.htm

Laser Institute of America

13501 Ingenuity Drive, Suite 128

Orlando, FL 32826

Tel: (800) 345-2737

Internet: www.laserinstitute.org

Compliance Engineering

70 Codman Hill Road

Boxborough, MA 01719

Tel: (978) 635-8580

International Electrotechnical Commission

Journal of the European Communities

EN60825-1 TR3 Ed.1.0—Laser Safety Measurement and Instrumentation

IEC-309—Plug, Outlet and Socket Coupler for Industrial Uses

Tel: +41 22-919-0211 Fax: +41 22-919-0300

Internet: <http://ftp.iec.ch/>

Cenelec

European Committee for Electrotechnical Standardization

Central Secretariat

rue de Stassart 35

B-1050 Brussels

Document Center

1504 Industrial Way, Unit 9

Belmont, CA 94002-4044

Tel: (415) 591-7600

Equipment and Training

Laser Safety Guide

Laser Institute of America
12424 Research Parkway, Suite 125
Orlando, FL 32826
Tel: (407) 380-1553

Laser Focus World Buyer's Guide

Laser Focus World
Penwell Publishing
10 Tara Blvd., 5th Floor
Nashua, NH 03062
Tel: (603) 891-0123

Lasers and Optronics Buyer's Guide

Lasers and Optronics
Gordon Publications
301 Gibraltar Drive
P.O. Box 650
Morris Plains, NJ 07950-0650
Tel: (973) 292-5100

Photonics Spectra Buyer's Guide

Photonics Spectra
Laurin Publications
Berkshire Common
PO Box 4949
Pittsfield, MA 01202-4949
Tel: (413) 499-0514

The heart of the *Evolution-30* system is an Nd:YLF laser rod pumped by three sets of four AlGaAs diode laser arrays (twelve arrays total). The laser light produced by the Nd:YLF laser rod is “frequency-doubled” to green light and emitted as energetic Q-switched pulses. The Q-switched pulse repetition rate is controlled by the user at rates from 1 to 10 kHz.

The laser pump chamber contains the Nd:YLF laser rod and diode lasers. The diode lasers “pump” the Nd:YLF rod; that is, their output excites the electrons of the neodymium atoms in the YLF crystal, which emit the 1053 nm light characteristic of their laser transition. The mirrors in the *Evolution-30* laser cavity are all highly reflective of 1053 nm radiation, so it is entirely contained inside the resonator.

This light is Q-switched by means of acousto-optic modulators to produce pulses from 100 to 350 ns long. The pulse duration depends on the pulse repetition rate and pump level, which are selected by the user.

The *Evolution-30* green output at 527 nm is produced by passing Nd:YLF-generated light through the frequency-doubling LBO (lithium triborate) crystal. In order to maximize the conversion of the fundamental wavelength to the green harmonic, the LBO crystal is placed inside the laser cavity where the fundamental beam is most intense (the conversion efficiency increases rapidly with the intensity of the fundamental light input). LBO offers excellent efficiency and a high damage threshold.

These 527 nm pulses exit the laser head from the forward output port or from the side output port if the internal turning mirror is used. The *Evolution-30* is ideally suited for pumping Ti:sapphire ultrafast amplifiers.

Nd:YLF Laser Material

The *Evolution-30* uses neodymium-doped lithium yttrium fluoride (Nd:LiYF₄, most commonly abbreviated as Nd:YLF) as its gain medium. Its long upper-state lifetime (470 μ s) provides efficient energy storage for high pulse energy operation at low repetition rates. The low thermal lensing and natural birefringence of Nd:YLF enable scaling to higher power without the loss of beam quality or the need for complex resonator designs.

As a birefringent material, Nd:YLF lases at two principle wavelengths: the 1047 nm (extraordinary) or the 1053 nm (ordinary) transition. Both lines originate on the same Stark split $^4F_{3/2}$ upper level. The good thermal conductivity of Nd:YLF allows efficient heat extraction, and its natural birefringence overwhelms thermally induced birefringence, eliminating the thermal depolarization problems of optically isotropic hosts like Nd:YAG.

The 1053 nm transition is used in the *Evolution-30* because of the somewhat higher absorption of the pump light by this transition, resulting in lower heat generation and, therefore, lower thermal lensing.

Acousto-Optic Q-Switching

An acousto-optic modulator (AOM) is a block of fused silica that acts as an optical phase grating when vibrated by an ultrasonic wave. The photoelastic effect couples the strain field of the ultrasonic wave to the optical index of refraction in the block. The resultant optical grating has a period and an amplitude set by the acoustic (ultrasonic) wavelength.

When a light beam is incident upon this grating, a portion of the intensity is diffracted out of the beam. By choosing beam parameters properly, a portion of any laser beam that attempts to circulate within the resonator experiences a diffraction loss that is sufficient to spoil the “Q” of the cavity and prevent lasing (i.e., there is no circulating beam).

With no circulating laser light available to pass through the laser medium, the pump energy builds up the gain to a higher level than would otherwise be present. (This is where the long lifetime of the upper-state laser level of Nd:YLF is beneficial).

The ultrasonic wave is impressed on the AOM by a piezo-electric transducer. Switching off the driving voltage to the transducer returns the AOM to its passive state of high optical transmission, and the laser resonator is returned to its high Q-state. The internal beam is no longer deflected but, instead, is amplified by the high gain now available in the Nd:YLF rod, and a powerful “Q-switched” laser pulse is emitted.

Re-applying voltage to the AOM with the transducer again spoils the cavity Q and allows the gain to rebuild to a high level. In order to hold off the very high circulating intensity in the *Evolution-30*, two synchronized AOMs are used. This process is repeated at the frequency at which pulsed laser output is desired, taking into consideration the characteristics of the laser.

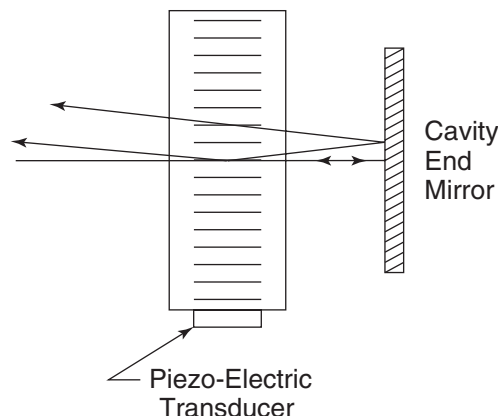


Figure 3-1: Acousto-Optic Modulation

Intracavity Frequency Doubling

Efficient frequency doubling requires power densities that are not normally available from a CW-pumped laser. Placing the nonlinear doubling crystal *inside* the resonator exposes it to high circulating power density. Power is coupled out of the resonator at the second harmonic wavelength by using an output mirror that is 100% reflective at the fundamental wavelength but transmits the second harmonic wavelength.

Intracavity frequency-doubling itself behaves in a manner that is somewhat analogous to an output coupler in a normal laser. It is only necessary that the conversion efficiency equals the theoretical optimum mirror transmission in order to completely convert the fundamental 1053 nm Nd:YLF wavelength into the green 527 nm second harmonic.

In order to achieve frequency-doubled output, the fundamental and second harmonic light must be “phase-matched” within the crystal; that is, the 1053 nm and the 527 nm waves must be in phase with each other over a reasonable length of the crystal. In order for this to occur, the index of refraction of the crystal must be the same at both the fundamental and the frequency-doubled wavelengths. However, since the wavelengths are substantially different, the two beams will be out of phase since each will see a different value for the index of refraction (unless special techniques are employed). Non-critical phase matching relies on the temperature dependence of the dispersion of the crystal to provide a match in the refractive index at the two wavelengths. As the name implies, non-critical phase matching is much less sensitive to the alignment of the crystal than other phase-matching schemes.

Lithium triborate (LBO) is a nonlinear optical crystal characterized by a relatively high optical damage threshold and a moderate nonlinear optical coefficient, as well as excellent material properties. LBO’s small birefringence allows for non-critical phase matching and provides a larger acceptance angle for high efficiency frequency conversion. The crystal must be heated and temperature-stabilized to maintain good conversion efficiency.

Laser Head Configuration

The laser head of the *Evolution-30* is shown in Figure 3-2. The laser resonator is a folded design, which reduces the overall size of the *Evolution-30* while simultaneously providing for efficient output coupling of the second harmonic light. The laser resonator contains the following components:

- (1) Nd:YLF curved, high reflecting (HR) mirror. This forms one end of the laser resonator.
- (2) 45° turning mirror, used to decrease the size of the laser head footprint.
- (3) The first AOM Q-switch (described below).
- (4) Diode laser pumped Nd:YLF laser chamber (described below).
- (5) Intracavity safety shutter.
- (6) Curved intracavity mirror, used to shape the beam inside the Nd:YLF rod.

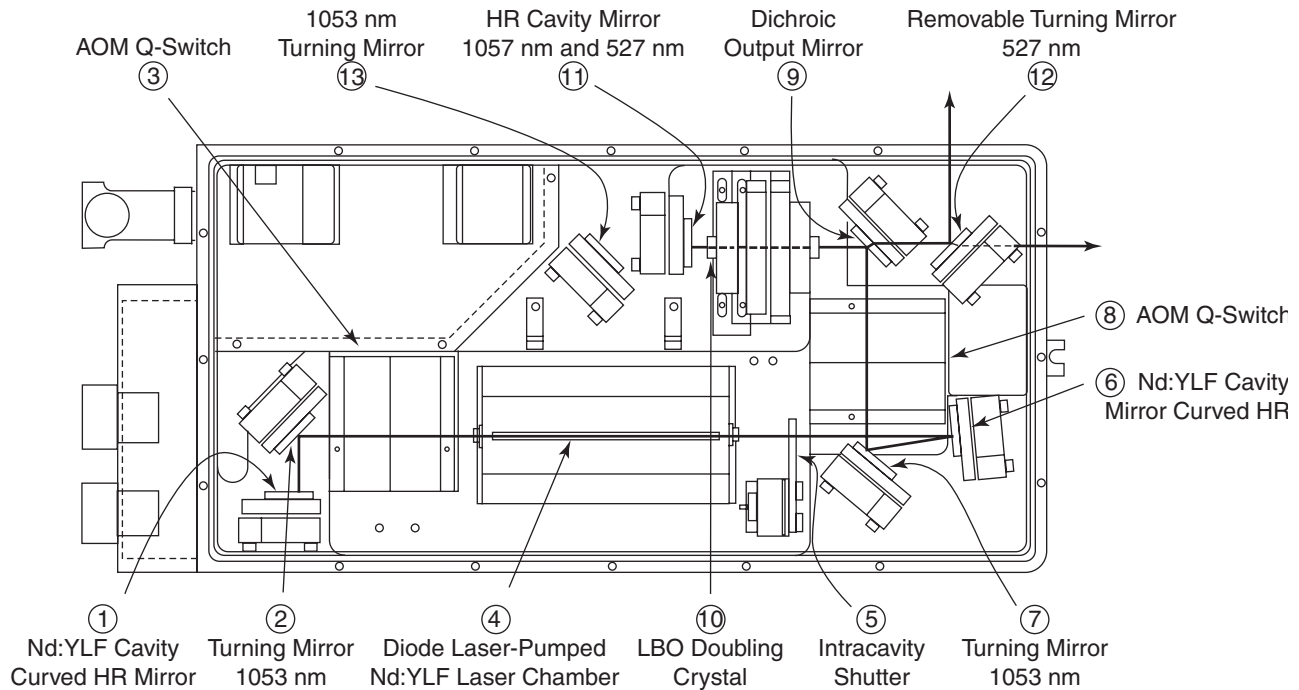


Figure 3-2: Laser Head Optical Layout

- (7) Another 45° turning mirror.
- (8) The second acousto-optic Q-switch. Two synchronized Q-switches are needed in the *Evolution-30* to hold off the high level of circulating laser light.
- (9) 45° intracavity dichroic folding mirror that is a high reflector at 1053 nm and has high transmission at 527 nm. This mirror serves to confine the Nd:YLF fundamental wavelength in the cavity while emitting the green output beam.
- (10) LBO frequency-doubling crystal in a temperature stabilized oven (described below).
- (11) Flat end mirror that is a high reflector at both 1053 nm and 527 nm. This forms the other end of the laser resonator, and also directs frequency-doubled light back toward the dichroic output mirror.
- (12)(13) 2 turning mirrors. The removable 527 nm mirror (12) directs the output through the side panel of the laser head. The 1053 nm turning mirror (13) is an aid to aligning and troubleshooting the resonator.

The beam waist is located at flat end mirror (11), so that the beam is diverging when it reaches one of the output ports. A lens located at either output port is then used to collimate the beam.

Component Descriptions

Laser Pump Chamber

The laser pump chamber contains the Nd:YLF laser rod and diode lasers. The chamber is mounted to the laser head in a mechanically indexed bracket that allows for easy extraction and insertion of the chamber. The laser rod is held with O-rings in a water flow tube that is surrounded by a gold-coated reflector. Slits in the reflector transmit the pump light from the diode lasers along the length of the rod. Both the laser rod and diode lasers are cooled by water that enters the pump chamber through manifolds in the bottom of the chamber.

The diode lasers themselves are arranged in three blocks of four high-power diode laser bars that are mounted 120° apart around the laser rod. Each block of bars is attached to a single water-cooled heat sink. The water flows in four separate parallel channels; one along the laser rod and three over the diode laser heat sinks. The diode lasers are electrically connected in series to the *Evolution-30* diode laser driver through a high-current connector on the pump chamber.

AOM Q-Switches

Two AOMs that function as Q-switches are enclosed in metal housings with coarse azimuthal adjustments. The AOMs are made of a high-quality fused silica to which RF transducers are bonded. The fused silica is cut and polished to be optically oriented at Brewster's angle for "s" polarized intracavity laser radiation.

Approximately 30 Watts of RF power are delivered to each AOM through two 50-ohm BNC cables. The AOMs are water cooled and have built-in temperature interlocks to shut off the RF power if an over-temperature condition occurs. The power for the AOM Q-switches is supplied from the *Evolution-30* power supply.

LBO Crystal and Temperature Controller

The LBO crystal is anti-reflection coated for both 1053 nm and 527 nm. It is located in an oven that maintains its temperature at a value set at the factory between 315° and 340°F, to within 0.1°F. At this factory-set temperature the crystal is non-critically phase matched for converting the intracavity 1053-nm wavelength efficiently to the second harmonic. The crystal should be constantly stabilized in this temperature range, even when the laser is not in use. If necessary, the crystal can be ramped down to room temperature for long-term storage of the laser (see Chapter 5, "System Operation").

The temperature controller is a pre-programmed microprocessor-based interlock device. If the LBO temperature is outside of the range of the factory set point (threshold values are also set at the factory), an indicator lamp will come on and an interlock will prevent operation of the laser.

Power Supply

The power supply assembly consists of a rugged steel frame in a 19 in. rack-mount configuration. The power supply contains the master control board, diode power supply, Q-switch RF driver, LBO crystal temperature controller, and other control electronics. In general, it should not be necessary to access any components inside the power supply.



Danger!



Potentially lethal voltages and currents are contained in the power supply. Removing the power supply cover will expose these hazards. Normal operation of the *Evolution-30* does not require access to the power supply circuitry. Contact an authorized service representative before attempting to correct any problem with the power supply.

Smart Analog PC Board

The master control pc board or “Smart Analog Board” (SAB) is a micro-processor-controlled system for setting and monitoring the diode laser power supply, laser interlocks, and Q-switch driver. It is controlled by software on the supplied computer through the RS-232 serial interface.

Diode Laser Power Supply

The diode laser power supply, which is controlled and monitored by the SAB, is a self-contained unit enclosed in a metal housing. The housing protects both service personnel and the components in the power supply.

Q-Switch Driver

The Q-switch driver provides RF power to the Q-switches in the laser head. It is an all solid-state electronic device consisting of a crystal-controlled oscillator, double-balanced modulator, pulse generator with gate and a broad band power amplifier that provides >30 W of drive power into each Q-switch. The driver is controlled and monitored by the SAB.

LBO Crystal Temperature Controller

The LBO doubling crystal is temperature tuned for non-critical phase matching. The crystal is housed in a temperature-stabilized oven. A resistive heating element combined with a local temperature sensor is used with the heater controller to stabilize the crystal temperature to within $\pm 0.1^\circ\text{F}$. The heater controller is programmed to limit the rate at which the crystal temperature is changed (typically no faster than 4°F per minute) to prevent cracking the crystal anti-reflection coatings. The power for the temperature controller is wired directly to the ac power lines so that the crystal is kept heated even when the front-panel breaker is turned off. The LBO crystal temperature should be ramped down before disconnecting power to the chassis (see Chapter 5, “System Operation,” for instructions).

The Control Computer

The *Evolution-30* comes with a commercial laptop computer pre-loaded with LabVIEW^{TM*} software that uses an RS-232 serial interface to control and monitor the functions of the laser. Although the particular computer delivered with each laser may vary, it is specified to have:

- a high-speed CPU
- ≥ 256 MB of RAM
- ≥ 10 GB hard drive
- a CD-ROM drive
- a floppy drive
- Windows XP Home Edition^{TM**} operating system

The control software for the *Evolution-30* is pre-installed on the laptop and tested with the laser. A copy of this software is delivered on floppy disk or CD-ROM.



Caution!



The *Evolution-30* was built and tested using the control computer and control software shipped with the laser. Use of any other computer or software for this purpose may cause damage to the laser, and may also void the warranty.

RS-232 Connection

The control computer is connected to the *Evolution-30* power supply using the DB-9F to DB-25M serial modem cable. By default, the software uses the COM1 serial connection on the laptop computer corresponding to the built-in serial port.

Control Software

The “Evolution-30 Control” software is accessed by a shortcut in the Start menu program folder. The exact layout of the front panel varies depending on the software version, but all versions share the same general controls. The latest version of the software is always available from Spectra-Physics.

Note



Some laptops provided with the *Evolution-30* system do not have serial ports. A USB-to-serial adapter is provided with these laptops.

* LabVIEW is a registered trademark of National Instruments

** Windows XP is a registered trademark of Microsoft

Performance Specifications

The table below lists performance specifications for the *Evolution-30* laser system. The environmental specifications are listed in the front of this manual. Utility requirements and mechanical specifications are listed in Chapter 4, “System Installation.”

Table 3-1: Specifications, *Evolution-30*

Output Characteristics ¹	1 kHz	5 kHz
Energy per Pulse	20 mJ	6.0 mJ
Beam Diameter	3 mm (nominal)	
Energy Stability ²	1% RMS	
Polarization	Linear, horizontal	
Transverse Mode ³	Multimode	
Wavelength	527 nm	
Repetition Rate	1 to 10 kHz	

¹ Due to our continuous product improvement program, specifications may change without notice.

² Rms with near Gaussian distribution.

³ Optimized for pumping Ti:Sapphire amplifiers.

The *Evolution-30* system must be installed by an authorized Spectra-Physics representative. Read this section thoroughly beforehand to prepare your site for installation, then call your authorized service representative to arrange an installation appointment, which is included as part of your purchase agreement. You may, however, unpack the laser and locate it in the area where it will be used. Refer to the unpacking instructions near the beginning of this manual.

Warning!



Do not attempt to install the laser yourself, or remove the lid sealing the laser cavity. Either action, if unauthorized, will void your warranty, and you will be charged for the repair of any damage that may result.

Location

Before installation, please select a suitable location for the *Evolution-30*. Spectra-Physics recommends the laser be located in a laboratory type environment that is free from dust and drafts, with low humidity (<50%) and has temperature fluctuations less than $\pm 5^{\circ}\text{C}$.

Pumping a Spitfire Amplifier

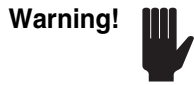
If used to pump a *Spitfire* amplifier, the *Evolution-30* should be placed relatively close to the *Spitfire*. The optimal distance between the two units is determined at the factory during the final test procedure. Deviations of greater than 6 inches from this distance can affect the overall performance of the system. Also, for safety reasons it is inadvisable to allow an exposed laser beam to travel a long distance. Please consult with your authorized service representative if necessary.

Required Utilities

Warning!



Do not apply ac line power to the power supply. Doing so will activate the LBO crystal heater. Any improper programming of the crystal heater and subsequent crystal heating will permanently damage the crystal. Such damage is not covered under the warranty. Installation of the *Evolution-30* laser should be performed by a service engineer.



The closed-loop chiller supplied with your *Evolution-30* is only compatible with a specific line voltage and frequency range. Do not attempt to operate the chiller at a different voltage or frequency under any circumstances.

Table 4-1: Utility Requirements for the *Evolution-30*

Destination	Acceptable Line Voltage/ Frequency (Vac/Hz)	Current Requirements (A)	
		Laser	Chiller
USA	(110 ± 10) VAC, 60 Hz	15	15
Japan	(110 ± 10) VAC, 50/60 Hz	15	15
	or (220 ± 22) VAC, 50 Hz	10	10
Europe	(220 ± 22) VAC, 50 Hz	10	10

Preparing to Install the Power Supply

To prepare for the installation of the power supply:

- The power supply must be placed within 10 feet (3 meters) of the laser head to avoid straining the umbilical.
- If possible, the power supply should be placed in a ventilated 19-inch equipment rack.
- For proper airflow, allow 6 inches (15 cm) of clearance to the front and back panels of the power supply.
- Take measures to prevent the heated air exhaust from the back panel fans from returning to the air intake on the right side panel as (as viewed from the back of the supply), or from flowing toward the laser head. Failure to do so may cause overheating in the power supply and instability in the laser output.
- Verify that the interlock jumper plug is in place on the back panel of the power supply. If you intend to use the laser in a limited access area, remove the jumper and wire it to a safety switch. The switch must be wired so that when the device is activated (for example, a door is opened) the switch opens and the laser turns off (see Chapter 2).
- Verify that the local line frequency and voltage are within the acceptable input ranges for the *Evolution-30* and the chiller as ordered.
- Ensure that the umbilical and all electrical cables can be safely routed without strain or compression.

Preparing to Install the Laser Head

To prepare for the installation of the laser head:

Note that the laser head is attached to the power supply via a 10-foot (3 meters) long umbilical. There are 4 cables inside: a 4-pin current cable, a 26-pin signal cable, and two BNC cables that connect to the RF OUT connectors on the back of the power supply.

To secure the laser head on an optical table or other flat mounting surface:

OEM *Evolution-30*

Two slots are provided at the center of the front and back of the laser housing for securing the laser head using standard table screws (M6 or 1/4-20) to fasten the laser to the table.

The arm at the front of the laser is bolted in place last, since securing this first will defeat its purpose in allowing for thermal expansion or contraction of the housing.

Scientific *Evolution-30*

Place the laser head on the table and adjust the four mounting feet to the correct height, making sure that the laser head is level. Lock the height of the feet using the locking ring on each leg. Secure the laser head to the table using a mounting clamp (supplied) on each foot.

Preparing to Install the Control Computer

The *Evolution-30* control computer needs to be within 10 feet (3 meters) of the power supply. The computer should be set up according to the manufacturer's instructions. Attach the 9-pin connector of the *Evolution-30* serial cable to the computer's serial output port, and attach the 25-pin connector to the RS-232 port on the power supply. For control computers shipped with Windows 2000, the default user name is "Administrator" and the default password is "PASS" (case-sensitive, no quotation marks). The *Evolution-30* control software is pre-installed on the control computer.

Preparing to Install the Chiller

- Verify that the local line frequency and voltage are within the acceptable input ranges for the chiller.
- The chiller will be located on the floor close enough to the *Evolution-30* that the cooling hoses will reach without strain.



Caution!



The chiller must be located so that the warm air exhaust from the back is not drawn into the laser power supply, which could affect the stability of the laser.

- Allow 6 inches (15 cm) of clearance between the chiller and the *Evolution-30* power supply, to prevent hot air from one unit being drawn into the other.
- The chiller should not be placed above the laser or power supply. If a leak ever developed in the chiller, dripping water could damage the unit below it.
- The hose connectors are attached so that the feed line (marked with an arrow pointing toward the laser head) is attached to the **lower** hose connector on the laser head. This will ensure that any air is purged upward and out of the laser head. (Connecting the chiller hoses in reverse would trip a flow interlock.)



Danger!



Before handling the OptiShield water treatment chemical, read Appendix A, “OptiShield Additive,” which describes the potential hazards of this substance and has instructions for its use. This chemical can be harmful if swallowed, inhaled or absorbed through the skin or eyes.



Caution!

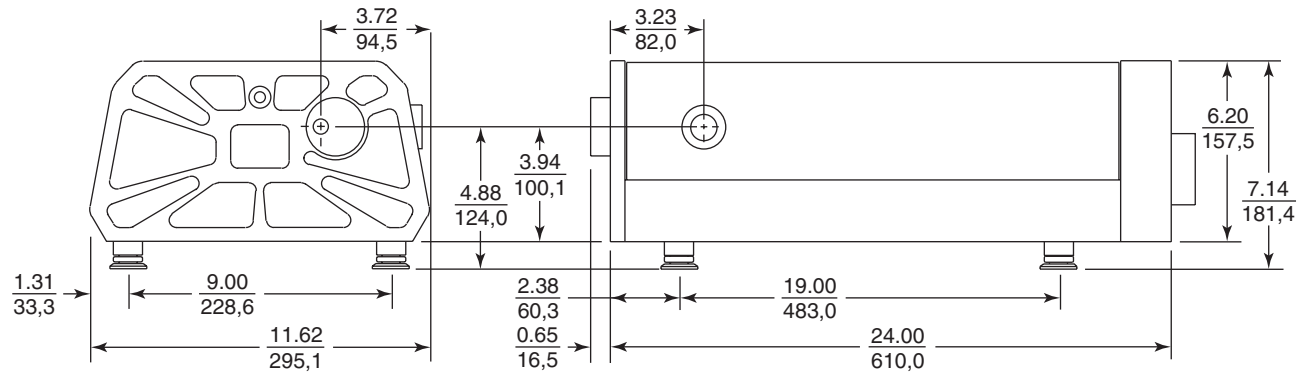


Use only **STEAM-DISTILLED** water in the *Evolution-30* cooling system. The use of de-ionized water may cause corrosion damage.

Mechanical Specifications

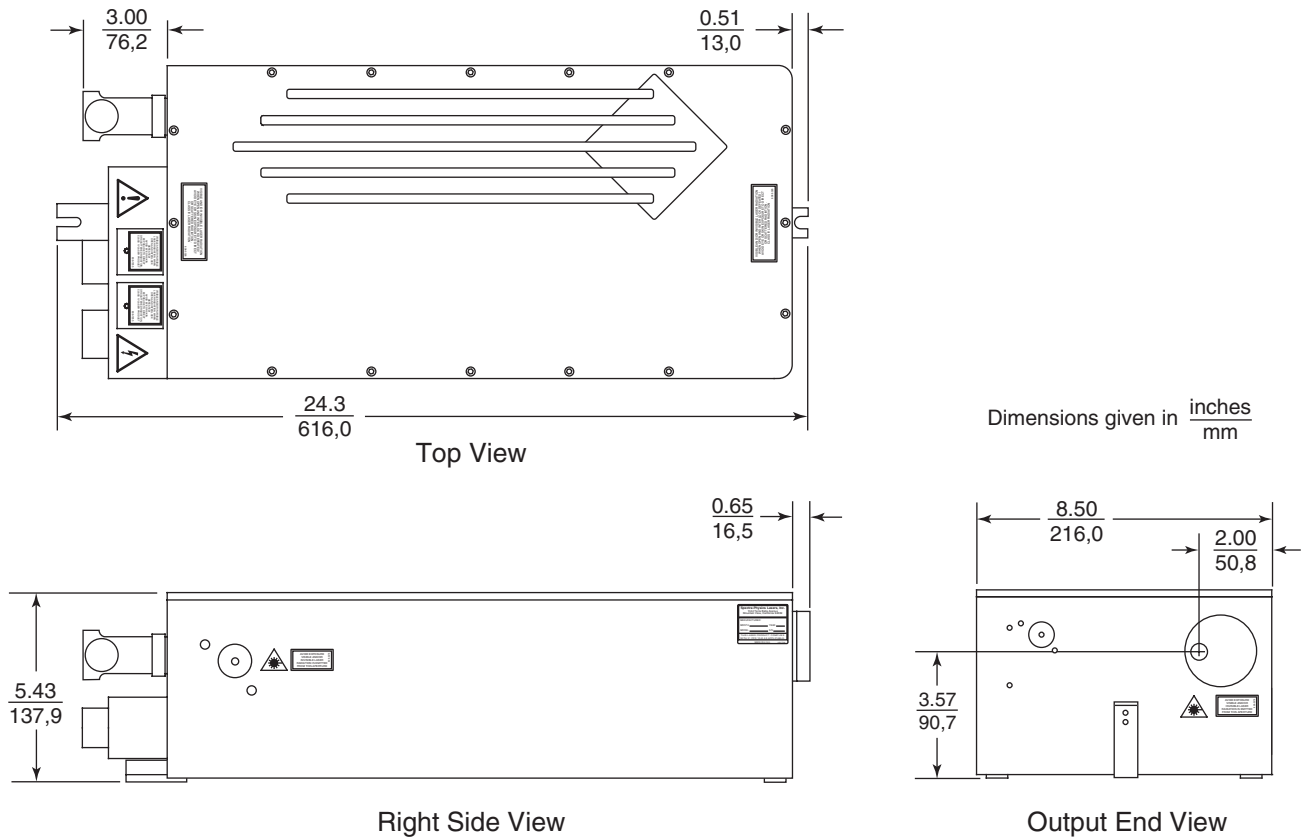
Table 4-2: Component Weights

Component	Weight
Laser Head (Scientific)	63.0 lb (28.6 kg)
Laser Head (OEM)	55.0 lb (25.0 kg)
Power Supply	46.0 lb (20.9 kg)
Chiller (dry, typical)	122 lb (55 kg)



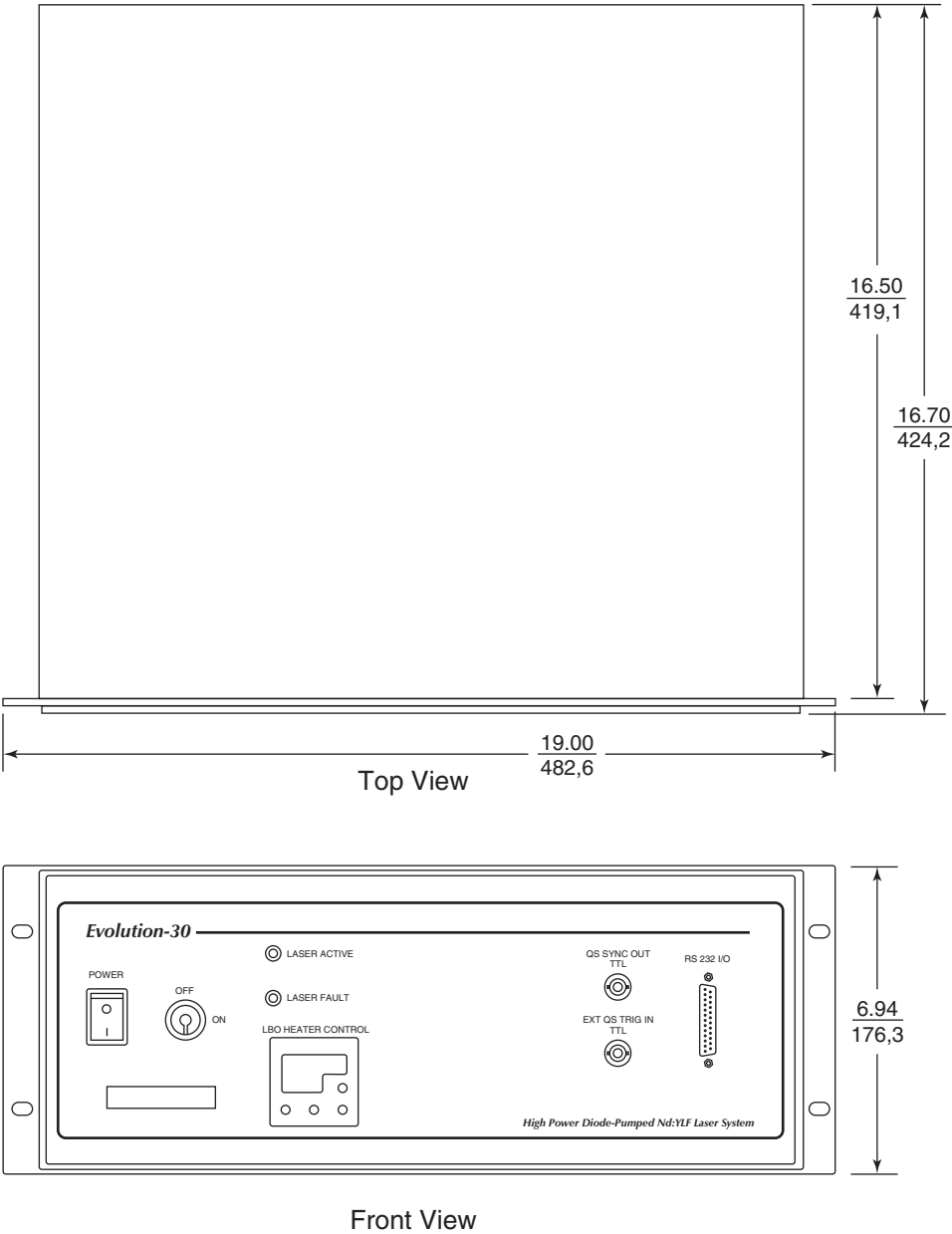
Dimensions given in $\frac{\text{inches}}{\text{mm}}$

Figure 4-1: Evolution-30 Scientific Laser Head Outline Drawing



Dimensions given in $\frac{\text{inches}}{\text{mm}}$

Figure 4-2: Evolution-30 OEM Laser Head Outline Drawing



Dimensions given in $\frac{\text{inches}}{\text{mm}}$

Figure 4-3: Evolution-30 Power Supply Outline Drawing

Note



A number of manufacturers produce chillers that are suitable for use with the *Evolution-30*. Consult the chiller manual included with the system for specifics about your chiller.

**Eyewear
Required**



Safety glasses for all lasing wavelengths must be worn at all times when operating this laser system. Consult your laser safety officer to select appropriate safety glasses. You **MUST** read “Chapter 2, Laser Safety.”

Overview

Routine operation of the *Evolution-30* is via the “Evolution-30 Control” software running on the host computer. It controls both the laser head and the power supply. Familiarize yourself with the operation of the power supply module and the control software described below before proceeding to the “Start-Up Procedure” later in this chapter.

Electrical Current Settings

The *Evolution-30* laser comes with a set of performance data that lists the factory-measured output power as a function of diode laser current at the nominal Q-switch repetition rate that was specified when the laser was ordered. Your authorized service representative will verify these measurements when the laser is installed.

It is useful to establish at least three nominal current settings: Low, Medium and High (for example, 15 A, 20 A and 25 A) that produce, for example, 6 W, 15 W, and 20 W for a standard 1 kHz system. This section will refer to these settings as Low, Medium and High. If the *Evolution-30* is not operated at its maximum specified output power, scale these settings appropriately when following the procedures in this chapter or when following any troubleshooting procedures.

After several hundred hours of operation the diode laser output power will decrease slightly. (This is a normal “burn-in” period.) The maximum possible current is set at the factory to ensure that the laser will meet its specified power for thousands of hours of operation.

Power Supply

The power supply contains the smart analog pc board (SAB), the diode power supply, the Q-switch RF driver, the LBO crystal temperature controller and other control electronics.

Power Supply Front Panel

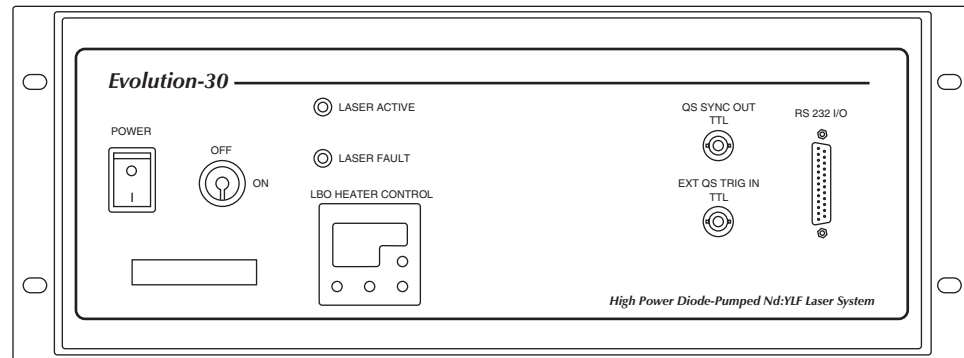


Figure 5-1: The Power Supply Front Panel

POWER switch—enables main ac line voltage to the power supply. The switch illuminates when power is turned on.



Danger!



AC line voltage to the LBO crystal heater circuit in the power supply is always present when the power supply is plugged in, even when the ac breaker is deactivated.

Keyswitch—the OFF position prevents operation of the laser, and removal of the key is possible only in the OFF position. The keyswitch is also used to reset latched interlocks by cycling the switch from OFF to ON.

LASER ACTIVE LED—illuminates when current is flowing through the diode laser arrays, regardless of the state of the laser output (Q-switched, cw, hold-off, etc.)

LASER FAULT LED—flashes when the *Evolution-30* encounters an interlock fault.

LBO HEATER CONTROL—is a controller that is programmed to maintain the temperature of the LBO crystal oven. Normally it is not necessary to change the settings of this controller.

RS232 I/O connector (25-socket D-sub)—provides RS-232 serial control of the system by a host computer.

QS SYNC OUT connector (BNC)—provides a fixed TTL signal out that is synchronized with the triggering of the Q-switch.

EXT QS TRIG IN connector (BNC)—triggers the Q-switch externally when a TTL signal capable of driving a 50 Ω load is applied. External triggering from 500 Hz to 10 kHz is possible. This mode requires the selection of “EXT” mode in the control software.

Power Supply Rear Panel

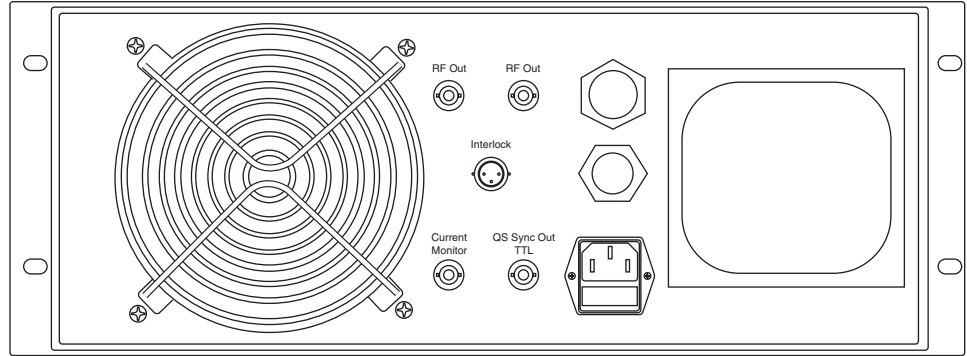


Figure 5-2: The Power Supply Rear Panel

AC IN connector—provides connection for the main input power source: either 110 Vac \pm 10%, 50/60 Hz, or 220 Vac \pm 10%, 50 Hz. Use the fuse size listed in Table 5-1.

Table 5-1: *Evolution-30* Fuse Specifications

Line Voltage/Vac	F1/F2: 3AG Slow Blow
200–240	10 A/10 A
100–120	15 A/15 A

RF OUT connectors (BNC)—output 30 watts each, 100–150 Vrms sine wave at 27.11 MHz into a 50 Ω load to drive the two *Evolution-30* Q-switches. DO NOT connect these signals to anything other than the BNC connectors present in the *Evolution-30* laser head umbilical.

26-pin connector (unlabeled)—supplies interlock and control signals to the laser head. Connects to the 26-pin umbilical cable.

4-pin connector (unlabeled)—supplies current to the diode laser arrays in the laser head. Connects to the 4-pin umbilical cable.

INTERLOCK connector (3-pin)—is used to interlock the laser via a controlled access point, such as a laboratory door. Pins J₁ and J₂ (shown in Figure 2-2) must be shorted in order to enable laser operation.

CURRENT MONITOR connector (BNC)—output that indicates the amount of current flowing through the diode arrays. The scale is 10 amps/volt.

Note



The power supply for the *Evolution-30* is similar in appearance to those used by other models of the *Evolution* laser family, but the power supplies are NOT interchangeable.

Control Software

The control software for the *Evolution-30* is called “Evolution-30 Control,” and it is accessed using a Windows shortcut found in the Programs folder of the START menu. The latest version of the software is always available from Spectra-Physics. This section describes the controls for the current version of the software (2.4.2).

Main Controls

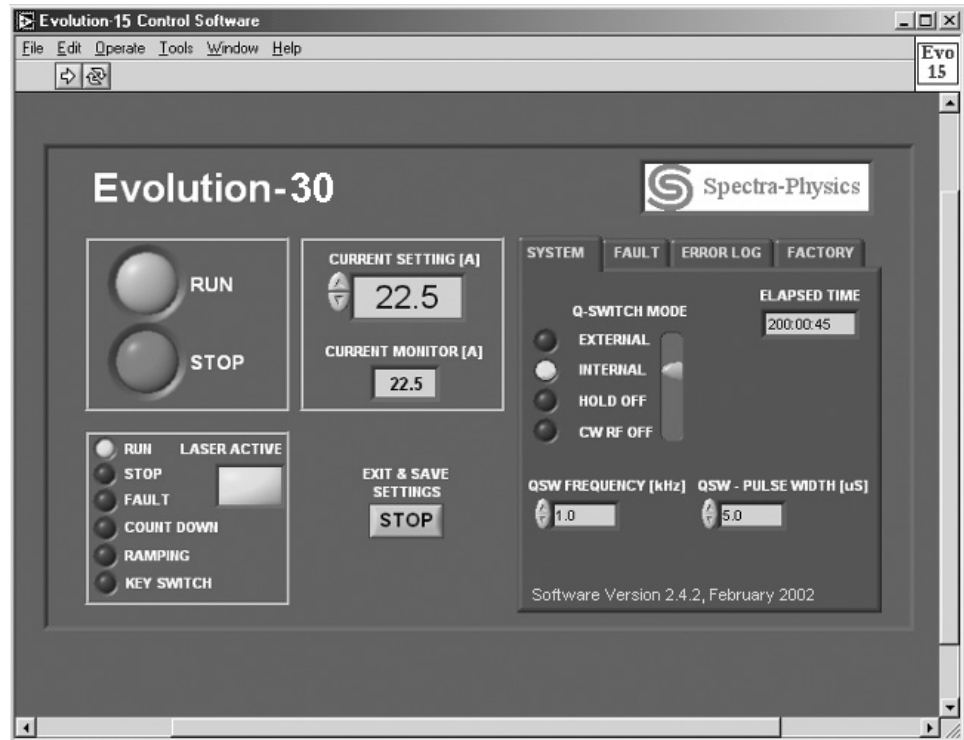


Figure 5-3: Evolution-30 Control Software

RUN/STOP control—simulates a push-button control that changes the state of the *Evolution-30* between RUN and STOP.

When the RUN state is selected, the diode laser arrays are activated and the LASER ACTIVE indicator comes on. The diode laser arrays begin a controlled ramp-up to allow time for the doubling crystal to maintain operating temperature. The RAMPING and COUNT DOWN indicators appear on the screen display. After a delay of 5 seconds, during which time a tone sounds, the *Evolution-15* begins to lase.

The RAMPING and COUNT DOWN indicators on the screen display turn off, and the emission LED on the power supply and the RUN indicator on the screen turn on.

In the STOP state, the *Evolution-30* stops lasing (the diodes are turned off and the internal shutter in the laser cavity is closed).

Note



When the laser is turned on for the first time after the power supply has been cycled, it initially defaults to the STOP state.

RUN, STOP, FAULT, COUNT DOWN indicators—are described above under “Run/Stop control.”

KEY SWITCH—shows the state of the access control key. It is illuminated if the key is in the OFF position and flashes if the keyswitch needs to be recycled to reset the Fault State.

LASER ACTIVE indicator—turns on when current is supplied to the diode lasers.

CURRENT SETTING [A] control—is a numeric control that allows setting of the diode lasers output current (in amps) up to the factory maximum set point. The numeric value can be entered directly or in 0.1 A steps using the adjacent buttons.

CURRENT MONITOR [A] meter—is a digital meter display of diode current (in amps).

EXIT and SAVE SETTINGS button—stops the laser (if it is running), stops the execution of the control program, and saves the settings.

The inset panel contains the display choices SYSTEM, FAULT, ERROR LOG and FACTORY, which are selected by tabs so labeled.

The panels associated with each of choices are described below.

SYSTEM Panel

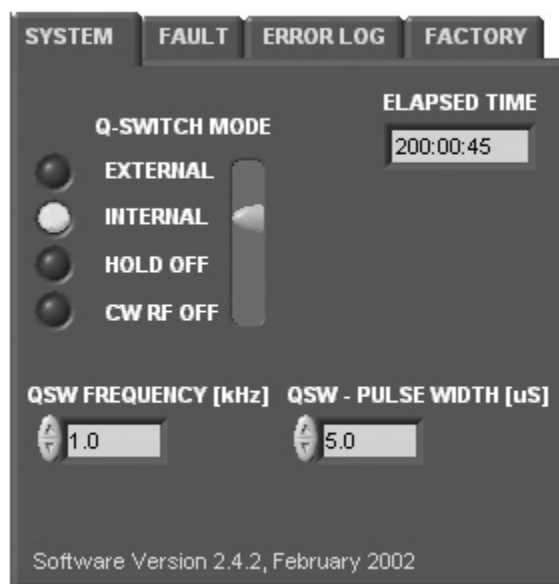


Figure 5-4: The Control Software SYSTEM Panel

QSW MODE control—sets the mode of the Q-switch driver and the indicators that show the active Q-switch mode:

EXTERNAL—RF power on, Q-switch trigger source is the **EXT QS TRIG IN BNC** on the front panel of the power supply. The external trigger frequency must be > 500 Hz or the laser will interlock.

INTERNAL—RF power on, Q-switch trigger source is the internal clock on the SAB, repetition rate set by the software QSW Frequency control.

HOLD OFF—RF power on, no Q-switch triggers. It is used to check alignment of the Q-switches during servicing of the laser.

CW RF OFF—(Continuous wave) RF power off. It is used for setting and checking laser cavity alignment during servicing of the laser.



Caution!



Changing from non-Q-switching modes (CW and HOLD OFF) to lasing modes (INTERNAL and EXTERNAL) while the laser is running will cause the laser to switch to Stop mode. When this happens, restart the laser by simply switching to Run mode.

QSW FREQUENCY [kHz] control—sets the frequency of the internal Q-switch trigger source.

QSW PULSE WIDTH [μ s] control—sets the width of the internal trigger pulse to the Q-switch driver.

ELAPSED TIME display—shows the cumulative hours and minutes of laser operation.

FAULT Panel



Figure 5-5: Control Software FAULT Panel

COVER/USER LED—turns on when any of the micro-switches on the laser head are *not* engaged or when the user interlock is open. Verify the covers are closed or that the interlocks are defeated on the laser head, and that the door interlock switch is closed or interlock defeated, then cycle the key-switch to clear the fault.

FLOW LED—turns on when chiller water flow is less than 2.0 GPM. Verify the chiller is functioning properly and that water pressure and reservoir level are correct, and that the water hoses are not kinked to ensure adequate flow, then cycle keyswitch to clear the fault.

LBO TEMP LED—turns on when the LBO temperature is outside a preset range around the factory set point. Allow the temperature to return to specified temperature range before turning on the system again.

QSW LOW FREQ LED—turns on when the QSW MODE is set to EXTERNAL and the external source of triggering drops below 500 Hz. Ensure that the source of external Q-switch triggering is producing TTL pulses at 500 Hz or higher.

QSW VSWR LED—turns on when either or both of the QSW RF connectors on the back of the power supply are disconnected.

QSW TEMP LED—turns on when the thermal sensor in either AOM exceeds the safe operating temperature for that device. Verify the chiller is functioning properly and that water pressure and reservoir level are correct, and that the water hoses are not kinked to ensure adequate flow, then cycle keyswitch to clear the fault.

COMM ERROR LED—turns on when communications are interrupted between the computer and the power supply. Check the serial cable connections and verify the power supply is turned on. Exit the Control Software, cycle ac power on the power supply, then restart the Control Software to clear the fault.

DRIVER TEMP LED—turns on when the temperature of the diode driver (FET) heat sink becomes overheated due to inadequate airflow to the driver, or to a shorted or over-current condition. Verify airflow in the power supply is adequate and allow the system to run without lasing for at least 10 minutes to cool it down, then restart the laser.

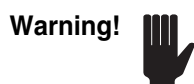
DIODE TEMP LED—turns on when the temperature sensor mounted in the laser pump chamber exceeds the safe operating temperature. Turn off the power supply and allow the chiller to run for 10 minutes to cool it down, verify proper chiller temperature, then restart the laser, running it at a lower diode laser drive current.

OVER VOLTAGE LED—turns on when the voltage required to supply the requested current to the diodes exceeds the factory-set limit. Check the diode umbilical connection and cycle power on the power supply to clear the fault.

OVER CURRENT LED—turns on when the current requested to drive the diode array exceeds the factory-set limit. Lower the current drive setting, then cycle power on the power supply to clear the fault.

OVER POWER LED—turns on when the internal drive FET exceeds a factory-set power limit. Reduce the diode drive current, then cycle the power on the power supply to clear the fault.

PROT FAULT LED—turns on when the internal drive FET protection circuit is activated. This is a serious internal driver failure that requires repair.



Do not operate the *Evolution-30* if a PROT FAULT error occurs!

CHECKSUM ERROR LED—turns on when a garbled communications message is detected between the Control Software and the *Evolution-30*. Normally these can be ignored, but if they occur frequently, check the RS-232 cable connections.

ERROR LOG Panel

This window displays all the fault conditions, fault corrections and their time stamps.

FACTORY Panel

The controls available under this tab are reserved for use in the factory. Do not use them!

Start-Up Procedure

Follow these procedures when starting and operating the *Evolution-30* laser system.

**Eyewear
Required**



The following procedures will result in laser emission from the *Evolution-30* output port. Ensure that all persons in the room are wearing adequate eye protection. Also ensure that the anticipated beam is safely terminated into a high power beam block or power meter.

1. Verify the power supply chassis is plugged in and the umbilical cables are connected properly.
2. Verify that the LBO Heater Control temperature is at the proper factory-set temperature.
3. Turn on the chiller.
4. Verify the control cable is connected between the computer and the power supply.
5. Boot the control computer and log in (if necessary).
6. Turn on the power supply power switch.
7. Insert the key in the keyswitch and turn it to the ON position.
8. Start the *Evolution-30* control software.

After the Control Software begins communicating with the *Evolution-30* and all interlocks are closed, the STOP indicator on the Control Software screen will turn on, indicating that the laser can be started.

If the FAULT indicator on the power supply flashes, or the FAULT indicator on the Control Software screen is on, refer to the Troubleshooting Guide in Chapter 7 for help in clearing the interlock faults.

9. Set the CURRENT SETTING on the Control Software screen to the nominal Low setting.

10. If the *Evolution-30* is to be internally Q-switched, set the QSW FREQUENCY control to the proper repetition rate (e.g., 1.0 kHz), and set the QSW MODE switch to INTERNAL.

**Caution!**

Your *Evolution-30* was optimized at a user-requested specific Q-switch repetition rate. Operating the laser at a significantly different rate may result in decreased performance or damage to the instrument.

11. If the *Evolution-30* is to be externally Q-switched, attach a TTL-level signal (at least 2.5 μ s duration) at the proper frequency to the EXT QS TRIG IN connector on the front panel of the power supply, and set the QSW MODE to EXTERNAL. Q-switch operation is synchronized to the rising edge of the input pulse.
12. Rotate the output shutter on the front or remove the plug from the side of the *Evolution-30* (depending on which port is being used) to the open position. Verify laser output will be directed into an appropriate termination (e.g., beam dump, power meter, *Spitfire*, etc.).
13. Slide the Laser State control on the Control Software screen to the RUN position. The LASER ACTIVE LED on the power supply will turn on, as will the LASER ACTIVE indicator on the Control Software screen. The CURRENT MONITOR will display the set-point level in approximately 5 seconds.

Please note that it takes the chiller about 15 minutes to stabilize the temperature of the laser head cold plate and, thus, the output of the laser. If the laser is used frequently, leaving the chiller on between periods of use will eliminate or greatly reduce this stabilization period. If the laser is used infrequently, turn off the chiller between periods of use.

14. Measure output power with a power meter capable of measuring 30 Watts minimum. Within several minutes, the 527 nm power should be the same as or close to the power that was previously measured at the Low current setting.
15. Manually increase the current setting at a rate of no more than 1 amp per second until the Medium-current setting is reached. Monitor the power continuously as you make this adjustment to ensure that the power increases monotonically with the current. If output power is low, wait 10 minutes for the laser temperature to stabilize. Once the power reaches the Medium-current setting, increase the current to the High setting and verify the power again. If the beam does not reach operating power, it may be necessary to optimize the lasing output as described in Chapter 6, "Maintenance."

System Shutdown

1. Click the STOP button on the Control Software screen. The shutter will close and the diodes will shut off immediately.
2. Close the Control Software window.
3. Turn the keyswitch to OFF and remove the key from the keyswitch.
4. Turn off the main power switch.
5. Turn off the chiller if the system is used infrequently.

Long Term Shutdown

If the *Evolution-30* will be disconnected from line voltage for an extended period of time (greater than a few minutes), follow this procedure to slowly ramp down the LBO crystal temperature to room temperature to avoid thermal shock to the crystal.

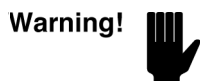
1. On the LBO Heater Control module on the front panel of the power supply, note the factory setting, then press and hold the down arrow button (lower right) until the temperature setting is 75°F or cooler.
2. Allow the crystal temperature to ramp down until it reaches 75°F.
3. Turn off the *Evolution-30* power supply and disconnect the power cord.
4. To return the *Evolution-30* to normal operation, plug in the power supply and reset the temperature to the factory-set temperature noted during shut-down. When the LBO crystal reaches the new set point, the laser can be operated normally.

The *Evolution-30* has been designed for minimal maintenance. The routine procedures described in this chapter are recommended to keep the system in good working condition. For further information, contact your Spectra-Physics service representative.

Lasing Optimization

Cavity Mirror Adjustments

All of the optical mounts in the *Evolution-30* are securely fastened to the rigid base plate of the laser head. Nevertheless, the mirrors may become slightly misaligned due to changes in room temperature, bumps or other stresses on the laser head. If this happens, the end mirrors of the laser cavity may require adjustment.



Improper adjustment of the *Evolution-30* laser can result in damage to the laser rod or LBO crystal. Do not attempt to adjust the *Evolution-30* mirrors until you have read this section. If you are uncertain about this procedure, contact your Service representative for assistance.



Protective eyewear **MUST** be worn for protection from all wavelengths emitted by the *Evolution-30*. Refer to Chapter 2, “Laser Safety,” in this manual.

Use the following procedure to optimize the cavity mirrors:

Materials required:

- Laser safety goggles
- Infrared viewer or card
- Two $\frac{1}{8}$ -inch ball-tipped Allen wrenches
- Calibrated power meter capable of measuring at least 30 watts

Procedure:

1. If the *Evolution-30* is lasing, stop the output by sliding the Laser State switch to STOP. It is not necessary to turn off the power to the power supply.
2. (Scientific version only) Lift the sheet metal cover from the laser head.
3. (Scientific version only) Locate the two interlock by-pass plates (with orange warning stickers) and use them to lock down the cover interlock switches. This allows the laser to be operated with the sheet metal cover removed. This step should be reversed and the cover replaced as soon as the optimization procedure has been completed.
4. Cycle the keyswitch on the power supply off and on to clear the cover interlock circuit fault.
5. Place the power meter at the *Evolution-30* output.
6. Set the QSW MODE to INTERNAL and the QSW frequency to 1.0 kHz.
7. Start the laser at the Low current setting, allow the power to stabilize and make note of the stable power level.
8. Remove the set screws covering the mirror adjustment ports on the corner of the laser head closest to the umbilical connection (Figure 6-1). Put the screws in a safe place.

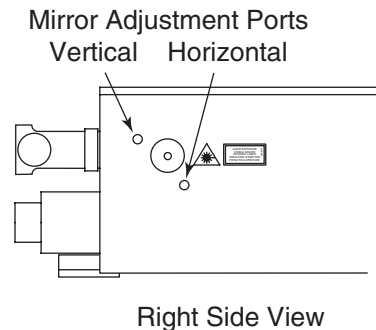


Figure 6-1: Access to End Mirror Adjustment Screws

9. Using the hex wrenches, carefully adjust the vertical screw (top-left port) of the end mirror while monitoring output power. Make **very small adjustments** (less than ½ turn total travel). Use this process to maximize output power. Make a note of the maximum stable power setting.
10. Using the same procedure, carefully adjust the horizontal screw (lower-right port) while monitoring output power. Again, make **very small adjustments** (less than ½ turn total travel). Use this process to maximize output power. Make a note of the maximum stable power setting.
11. Set the Laser State switch to STOP and set the QSW MODE switch to HOLD OFF.
12. Set laser current to the Low setting and the power meter to its most sensitive reading.

13. Click on RUN on the screen display to start the *Evolution-30*, then use an infrared viewer or card to verify there is no visible or infrared output from the laser. If any is detected, **turn off the laser** and contact Spectra-Physics for assistance.
14. Slowly turn up the current to the High setting while monitoring laser power. Power should remain at zero as the current ramps all the way up to the maximum current setting. As in the previous step, verify that there is no visible or infrared output, and if any is detected, **turn off the laser** and contact Spectra-Physics for assistance.
15. Click on STOP on the screen display, then slide the QSW MODE selector to INTERNAL, set laser current to the Low setting and restart the laser with the Laser State switch. Note the output power level.
16. Fine-tune the vertical and horizontal adjustment screws on the mirror to return output power to the maximum value previously recorded.
17. Once output power is optimized, slowly turn up the power control to the Medium current setting, and then to the High setting while monitoring the power meter. When the current reaches the High setting, allow the laser to stabilize, and note the stable power level.
18. If, at any time, laser power starts to fluctuate rapidly, **turn off the laser** and contact Spectra-Physics for assistance.

If this procedure does not cause the *Evolution-30* to meet its specified power, it may be necessary to optimize the LBO crystal temperature (see the procedure below).

LBO Crystal Temperature Optimization

Depending on environmental conditions, the optimum LBO crystal temperature for efficient intracavity doubling may vary slightly from the factory set point. LBO crystal temperature can be varied plus or minus 1.5°F around the factory-set temperature to compensate for environmental effects.

Warning!



If, at any time, while optimizing the LBO temperature at the Medium current setting output power drops by more than 20%, **turn off the laser immediately**. (Optical damage could occur if the LBO temperature is severely detuned, resulting in insufficient second harmonic light being coupled out of the optical resonator.) Perform the optimization procedure described below. If you are uncertain about this procedure, contact your authorized Spectra-Physics service representative for assistance.



Caution!



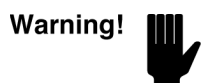
If the temperature of the LBO heater deviates from the factory setting by more than 1.5°F, an LBO TEMP fault will occur. In this event, return the setting to the factory setting and restart the optimization procedure, but in the opposite temperature direction. If you still believe the optimum LBO temperature setting is more than 1.5°F away from the factory setting, contact your authorized Spectra-Physics service representative.

To optimize the LBO temperature:

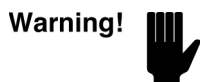
1. Note the present temperature setting as displayed on the LBO temperature controller screen.
2. Set the laser current to the Medium setting, turn on the laser and allow it to stabilize for 10 minutes. Note power output with a power meter.
3. While monitoring output power, use the up/down arrows on the LBO HEATER CONTROLLER to change the temperature set point by 0.5°F. After the temperature stabilizes at the new setting, again note output power. If power has increased, change the temperature by another 0.5°F in the same direction. If it decreased, change the temperature by 0.5°F in the opposite direction. Repeat this until the power is maximized.
4. When output power has been maximized, make a note of the temperature setting for future reference.

Cleaning the Optics

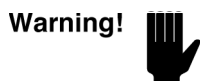
The *Evolution-30* is sealed against dust and debris, but depending on the cleanliness of the environment, it is possible that some dust may get into the laser head. When this happens, clean the optics.



Cleaning the optics will require opening the optical cavity. This procedure should not be performed without prior approval of your authorized Spectra-Physics service representative. Unauthorized opening of the seal will void your warranty and may damage your laser.



Cleaning the optics may result in misalignment of the laser cavity. After cleaning, the cavity should be realigned using the procedure earlier in this chapter.



The *Evolution-30* is assembled with chemically-cleaned parts. To prevent contamination, wear plastic gloves or finger cots while working inside the housing.

Materials required:

- Safety goggles
- Clean plastic gloves or finger cots
- Lens cleaning tissue (Kodak brand or equivalent quality)
- Reagent-grade methanol or acetone
- Eye dropper
- Hemostat (surgical pliers)
- English hex-wrench set
- Bright lamp or flashlight

**Danger!**

The LBO crystal is kept above 320°F (160°C). Prolonged contact with the LBO crystal housing can burn skin, melt plastic and ignite flammable material.

Warning!

Never attempt to clean the LBO crystal or the Nd:YLF laser rod in this system. Optical damage will occur and warranty will be voided if either of these two optics have been tampered with. If you feel that optical damage has occurred or cleaning of these optics is necessary, contact your authorized Spectra-Physics service representative.

Accessing the *Evolution-30* optics

1. Turn off the *Evolution-30* power supply.
2. (Scientific version only) Remove the external sheet metal cover.
3. Remove the screws holding the machined metal cover in place and put the screws in a safe place.
4. Remove the machined cover and place it on a clean surface.

Mirrors

Mirrors should be carefully cleaned with soft optical tissue and reagent-grade methanol or acetone.

1. Fold a piece of lens tissue repeatedly to form a pad approximately 1 cm wide.
2. Hold the pad with the hemostat so that about 3 mm of the folded edge protrudes from the hemostat.
3. Saturate the pad with methanol or acetone and shake to remove excess solvent.
4. Reach slightly below the center of the optic and wipe the surface of the optic toward the outside in one motion. Be careful that the hemostat does not touch the optic or the surface will be damaged.
5. If cleaning the intracavity dichroic mirror, repeat this operation using a clean tissue on the other optical surface.

Q-Switch

The Q-switch can be difficult to clean; attempt to clean it only if dust or debris are clearly visible. When cleaning the Q-switch crystal faces, it is necessary to remove the U-shaped cover around the Q-switch in order to gain unobstructed access to the quartz faces. **Do not** touch the transducer connections.

Routine Maintenance—Cooling Water

To prevent metal corrosion and growth of algae in the *Evolution-30* closed-loop cooling water system, OptiShield® corrosion inhibitor is recommended. This chemical treatment prevents galvanic corrosion from dissimilar metals, prevents oxidation of ferrous metals and acts as an effective algaecide. The first application of OptiShield is normally performed at the factory and a similar application will be repeated during system installation. Thereafter, for most *Evolution-30* systems the OptiShield solution should be changed once a year according to the following procedure.



Danger!



Before handling the OptiShield water treatment chemical, read the Material Safety Data Sheet included in Appendix A. This sheet describes the potential hazards of this material and provides handling precautions associated with it. *This chemical can be harmful if swallowed, inhaled or absorbed through the skin or eyes.*



Caution!



Use only **STEAM-DISTILLED** water in the *Evolution-30* cooling system. The use of de-ionized water may cause corrosion damage.

Periodic changing of solution:

1. Drain the old fluid from system.
2. The chiller has a 2-gallon capacity. Refill the reservoir with 2 pints of OptiShield and the remaining volume (14 pints) with **steam-distilled** water.
3. Turn on the chiller and verify that water is flowing (e.g., the flow interlock has not been activated). Inspect for leaks at the hose connections between the laser head and chiller.
4. Turn off the chiller.

OptiShield is a registered trademark of Opti Temp, Inc.

Troubleshooting Guide

This general-purpose troubleshooting guide is provided to assist you in isolating some of the problems that might arise during use of the *Evolution-30* laser system, for example, if performance drops unexpectedly. A complete repair procedure is beyond the scope of this manual and should be addressed by your authorized Spectra-Physics service representative.

Symptom: Laser will not start

Possible Cause:	Corrective Action:
No ac line power.	Check whether red AC POWER LED is lit. If not, verify that breaker on front of power supply is in the correct position; verify that the power cord at the rear of supply is tight; verify that the fuse is good.
Interlocks are not closed.	Check the LASER FAULT LED on the power supply and the FAULT panel of the software. If interlock indicators are on, turn the keyswitch off and back on to clear latched interlocks. Investigate any interlocks that are not cleared by this action. For example, verify that the chiller is turned on and the hoses are not constricted; verify that the laser head cover is on; verify that the user interlock is in place; etc. Refer to Chapter 2 for more information on interlocks.
Key switch is not in the ON position.	Turn the key switch to the ON position (horizontal). The key cannot be removed when it is in this position.
Communications error with the control computer.	Verify that there is a good connection with the 9-pin to 25-pin serial cable. Exit the Control Software application, then turn off ac power to the power supply, wait 5 seconds, turn on power again and restart the Control Software.

Symptom: Emission light comes on, but no output

Possible Cause:	Corrective Action:
Output shutter is closed.	Rotate shutter to the open position or remove the plug from the side port.
QSW MODE set to HOLD OFF.	Change the setting of the QSW MODE selector in the SYSTEM screen of the Control Software.
Cavity optics are out of alignment.	If the cavity optics are so far out of alignment that the laser will not start, contact your authorized service representative.

Symptom: Variations in output power

Possible Cause:	Corrective Action:
LBO crystal temperature has drifted.	Check the output power across the tuning range of the LBO crystal for the highest output power, as described in Chapter 6: Maintenance.
Water temperature variation.	Verify that the water chiller temperature is adjusted to the temperature that was set when it was installed (typically in the range of 18–27°C).
Cavity optics are out of alignment.	Adjusting the cavity mirrors slightly may optimize the output power. Read the detailed instructions in Chapter 6, “Maintenance,” before attempting to adjust the mirrors.
Optics are dirty.	Inspect the optics for dirt or contamination. If dirty, clean them as described in Chapter 6.
Q-switch breakthrough.	With the current at the High setting, turn the QSW MODE selector to the HOLD OFF position and turn the laser on. Using an infrared viewer or card, verify that there is no infrared and/or visible output beam from the laser. If there is any laser output, the Q-switch is malfunctioning or misaligned. Contact your authorized service representative.

Symptom: Power is below specification

Possible Cause:	Corrective Action:
Diode current is set too low.	Verify the expected output power levels for the Low, Medium and High settings.
Q-switch frequency is set higher or lower than 1 kHz.	Power output depends on Q-switch frequency. If operating the <i>Evolution-30</i> at a different Q-switch frequency than specified, contact Spectra-Physics for the power specification at that particular frequency.
Cavity optics are out of alignment.	Adjusting the cavity mirrors slightly may optimize the output power. Read the detailed instructions in Chapter 6, "Maintenance," before attempting to adjust the mirrors.
LBO crystal temperature has drifted.	At low pump power, check the output power across the 3-degree tuning range of the LBO crystal for the highest output power.
Algae growth is present in the cooling water.	Follow the maintenance procedure in Chapter 6.
Diode laser power is low.	After several thousand hours of operation, the optical power of the diode lasers decreases and the current to the diodes must be increased to compensate. Contact your service representative.

Symptom: Laser does not emit Q-switched or CW output

Possible Cause:	Corrective Action:
External Q-switch input is not valid.	If an external Q-switch signal is being used, verify the signal is at least 2 V into a 50-ohm load and at least 2.5 μ s wide; also verify the frequency is the desired value (between 1–10 kHz).
QSW MODE is set to CW RF OFF.	Change the setting of QSW MODE to INTERNAL.
QSW BNC cable is removed.	If either QSW cable has been removed, the <i>Evolution-30</i> will report a VSWR error and change the QSW MODE to CW RF OFF. Verify both BNC cables are attached at both the power supply and laser head.

Customer Service

At Spectra-Physics we take pride in the durability of our products. We place considerable emphasis on controlled manufacturing methods and quality control. Nevertheless, even the finest precision instruments need occasional service.

Warranty

This warranty supplements the warranty contained in the specific sales order. In the event of a conflict between documents, the terms and conditions of the sales order shall prevail.

The *Evolution-30* is protected by a twelve-month warranty. All mechanical and optical parts and assemblies are unconditionally warranted to be free of defects in workmanship and material for the warranty period. At its election, Spectra-Physics will repair or replace without charge components that prove defective during the warranty period. The obligation of Spectra-Physics is limited to repair covered under the warranty return procedure described below. Equipment repaired or replaced is warranted only for the remaining original warranty period.

This warranty is in lieu of all other warranties, implied or expressed, and does not cover incidental or consequential loss.

Spectra-Physics will provide at its expense all parts and labor and one-way return shipping of the defective part or instrument (if required).

This warranty does not apply to any instrument or component not manufactured by Spectra-Physics. When products manufactured by others are included in Spectra-Physics equipment, the original manufacturer's warranty is extended to Spectra-Physics customers. When products manufactured by others are used in conjunction with Spectra-Physics equipment, this warranty is extended only to the equipment manufactured by Spectra-Physics.

This warranty does not apply to equipment or components that, upon inspection by Spectra-Physics, discloses to be defective or unworkable because of abuse, mishandling, misuse, alteration, negligence, improper installation, damage in transit, or other causes beyond the control of Spectra-Physics.

Return of the Instrument for Repair

Contact your nearest Spectra-Physics field sales office, service center or local distributor for shipping instructions or for an on-site service appointment. You are responsible for one-way shipment of the defective part or instrument to Spectra-Physics.

We encourage you to use the original shipping boxes. If the original boxes have been destroyed or lost, we recommend that you order new ones. We will return instruments only in Spectra-Physics containers.

Service Centers

Benelux

Telephone: (31) 40 265 99 59

France

Telephone: (33) 1-69 18 63 10

Germany and Export Countries*

Spectra-Physics GmbH
Guerickeweg 7
D-64291 Darmstadt
Telephone: (49) 06151 708-0
Fax: (49) 06151 79102

Japan (East)

Spectra-Physics KK
East Regional Office
Daiwa-Nakameguro Building
4-6-1 Nakameguro
Meguro-ku, Tokyo 153
Telephone: (81) 3-3794-5511
Fax: (81) 3-3794-5510

Japan (West)

Spectra-Physics KK
West Regional Office
Nishi-honmachi Solar Building
3-1-43 Nishi-honmachi
Nishi-ku, Osaka 550-0005
Telephone: (81) 6-4390-6770
Fax: (81) 6-4390-2760
e-mail: niwamuro@splasers.co.jp

United Kingdom

Telephone: (44) 1442-258100

United States and Export Countries**

Spectra-Physics
1330 Terra Bella Avenue
Mountain View, CA 94043
Telephone: (800) 456-2552 (Service) or
(800) SPL-LASER (Sales) or
(800) 775-5273 (Sales) or
(650) 961-2550 (Operator)
Fax: (650) 964-3584
e-mail: service@splasers.com
sales@splasers.com
Internet: www.spectra-physics.com

*And all European and Middle Eastern countries not included on this list.

**And all non-European or Middle Eastern countries not included on this list.

This section contains the material safety data sheet supplied by the vendor of the algaecide used in the *Evolution-30* closed-loop cooling system. Please read this information before handling or disposing of this chemical or any cooling water containing it.

This information does not pertain to, and may not be appropriate for, larger quantities of the chemical than those described. The product is intended for use by personnel with sufficient technical skill and qualification to use the material correctly and who understand the risks involved in handling any potentially hazardous chemical.

Warning!



This information, obtained from the manufacturer, is believed to be reliable and accurate but has not been verified independently by Spectra-Physics. Accordingly, no representation or warranty, expressed or implied, with respect to merchantability and fitness for a particular purpose is made in this data sheet. For further information, contact the manufacturer at the address listed.



Caution!



Use only **STEAM-DISTILLED** water in the *Evolution-30* cooling system. The use of de-ionized water may cause corrosion damage.

Filling the Chiller for First Time Use

1. Flush the cooling circuit with distilled water.
2. The chiller reservoir has a 2-gallon capacity. Fill it with 1 pint of Optishield fluid and the remaining volume (15 pints) with **steam-distilled** water.
3. Circulate this solution for about 30 minutes.
4. Drain the fluid. **Do not rinse.** Continue as for periodic changing of solution (see below).

OptiShield is a registered trademark of Opti Temp, Inc.

Periodic Changing of Solution

1. After draining the fluid, refill the reservoir with 2 pints of OptiShield fluid and the remaining volume (14 pints) with **steam-distilled** water.
2. Turn on the chiller and verify that water is flowing. Inspect for leaks at the hose connections between the laser head and chiller.
3. Turn off the chiller.

Please note that it takes the chiller about 15 minutes to stabilize the temperature of the laser head cold plate and, thus, the output of the laser. If the laser is used frequently, leaving the chiller on between periods of use will eliminate this stabilization period. If the laser is used infrequently, turn the chiller off between periods of use.

MSDS Sheet for Optishield**MATERIAL SAFETY DATA SHEET**

OPTISHIELD®

Page 1 of 2

DATE REVIEWED: July, 2001**DISTRIBUTOR:**

OPTI TEMP INC.
P.O. Box 5246
Traverse City, Michigan
49696
(Collect)

Telephone: 231-946-2931
Emergency Hot Line
Chem-Tel 800-255-3924
International 813-977-3668

USE OF PRODUCT: Treatment of select cooling water systems.**SECTION I - Product Identification**

Special Components Chemical Names

This is a proprietary blend which contains the following components:

Name	% In Product
Sodium Nitrate	<1%
Sodium Molybdate	1-2%
Sodium Hydroxide	1-2%
Phosphoric Acid	<1.5%
Triazole	<2.5%

The Hazardous Materials Index Rating is as follows: Health=1; Flamability=0;
Reactivity=1

SECTION II- Physical Data

% Volatiles: Nil

Color: Light Golden-Yellow

Odor: Mild

Specific Gravity: 1.03

Solubility: 100% in water

pH of 100% solution (concentrated) 11 to 12; typical 11.5

SECTION III - Fire and Explosion Hazard

Non-Flammable

Flash Point: Unknown

SECTION IV - Reactivity Data

Stability: Stable

Polymerization: None

Exposure to Other Chemicals: Keep away from concentrated acids

Reactivity in Water: None

SECTION V - Shipping Information

Regulation: This material is not a DOT regulated material.
This product is a freezable liquid when and where applicable.

SECTION VI –Spill

Small spills: Small spills may be soaked up using common absorbent material, and using appropriate safety equipment. Dispose of and handle in accordance with local, state, and federal regulations.

Large spills: Large spills should be pumped into suitable containers located in diked areas. Residual material should be cleaned up with water. Dispose of and handle in accordance with local, state, and federal regulations.

SECTION VII - First Aid

Ingestion: Give milk or water, induce vomiting, get medical attention.

Skin: Flush with fresh water, wash with soap and water. Remove contaminated clothes and shoes.

Eyes: Flush with fresh water for at least 15 minutes. Get medical attention.

Inhalation: Inhalation should not occur during normal operation. However, should it occur, close container and move to well-ventilated area. If irritation persists, get medical attention.

SECTION VIII - Special Instructions

Do **NOT** pressurize container.

Keep container closed at all times when not in use.

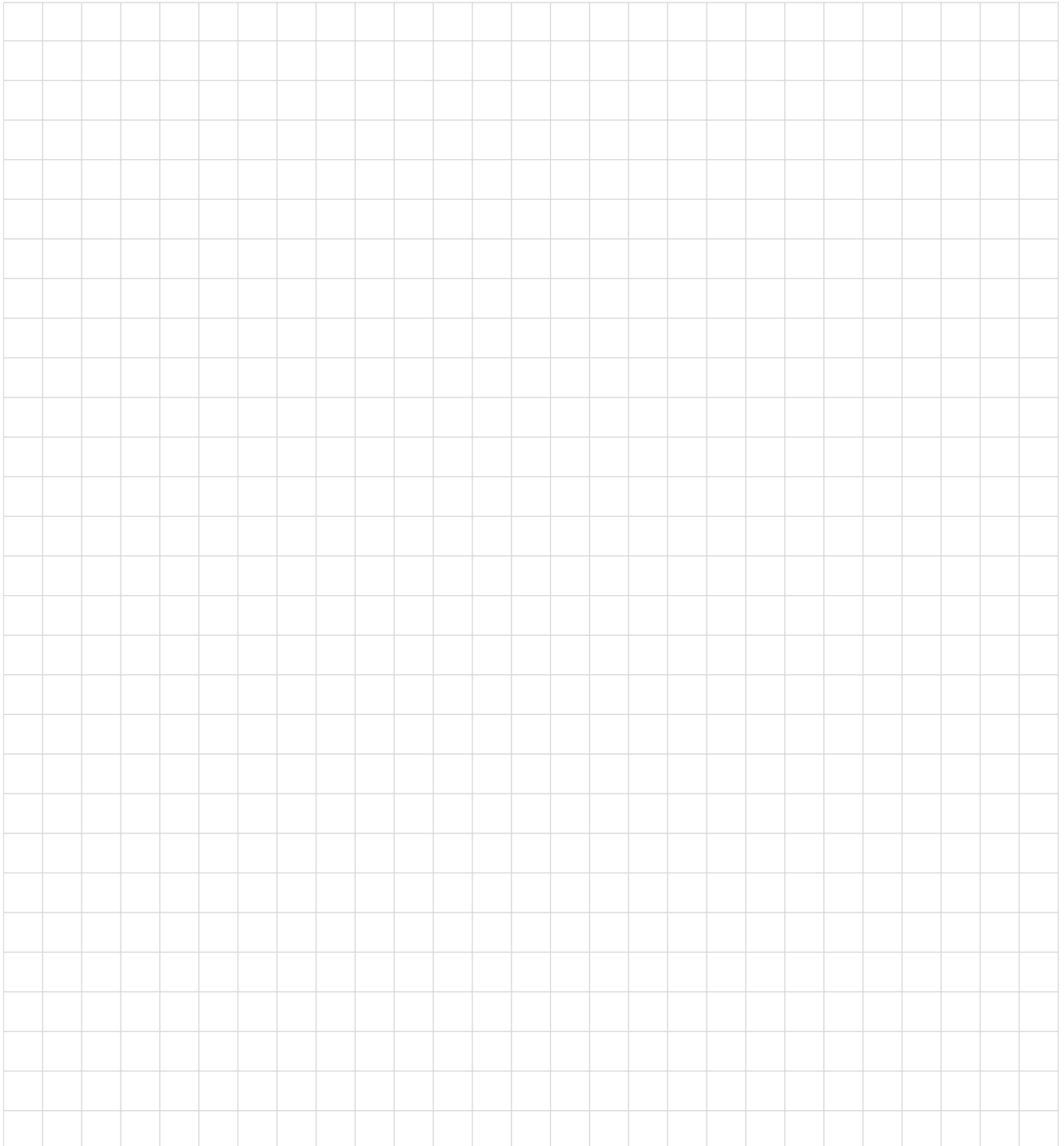
Store in cool area above 60°F. Do not allow fluid to freeze.

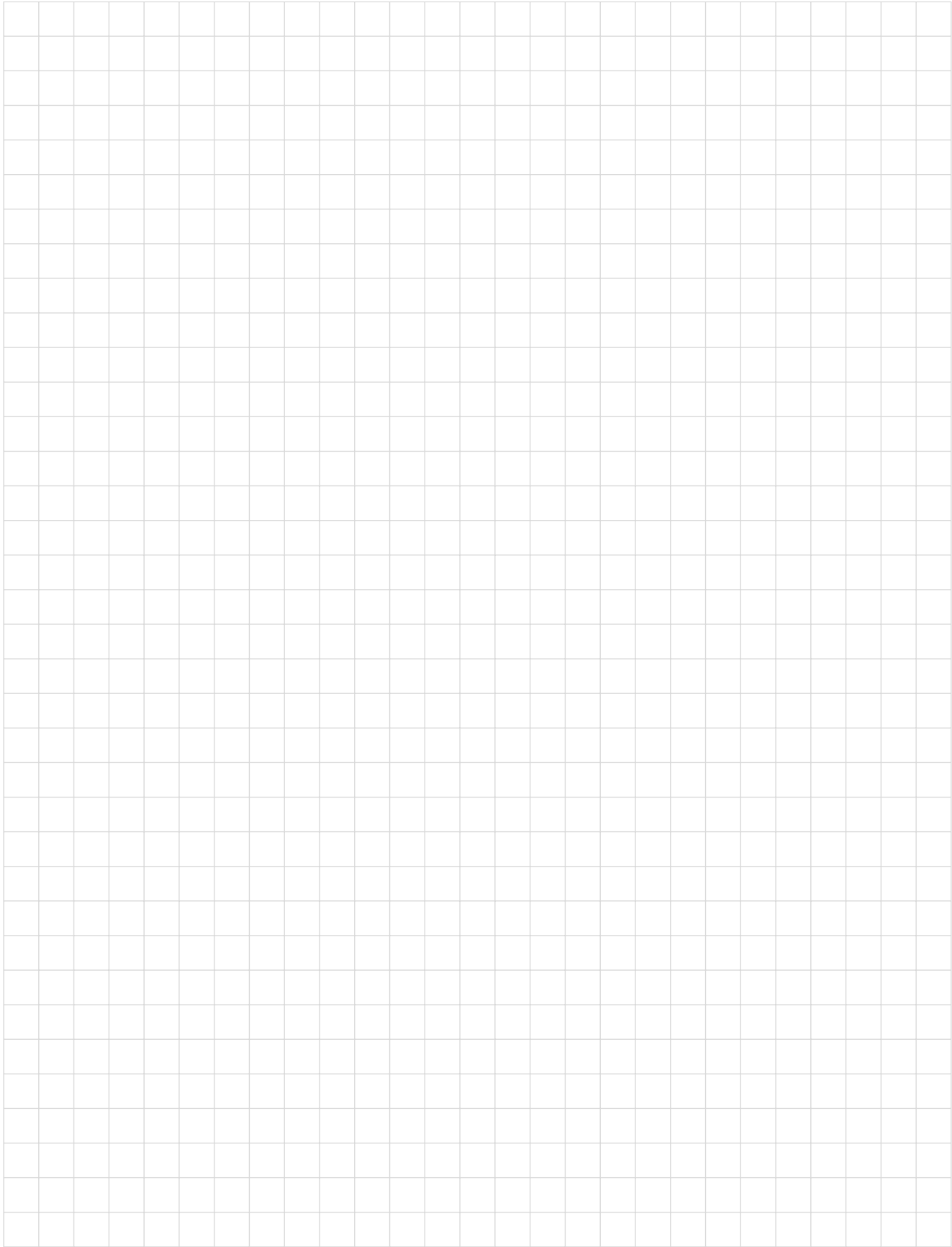
Use in well-ventilated area. Do not breathe mist or vapor.

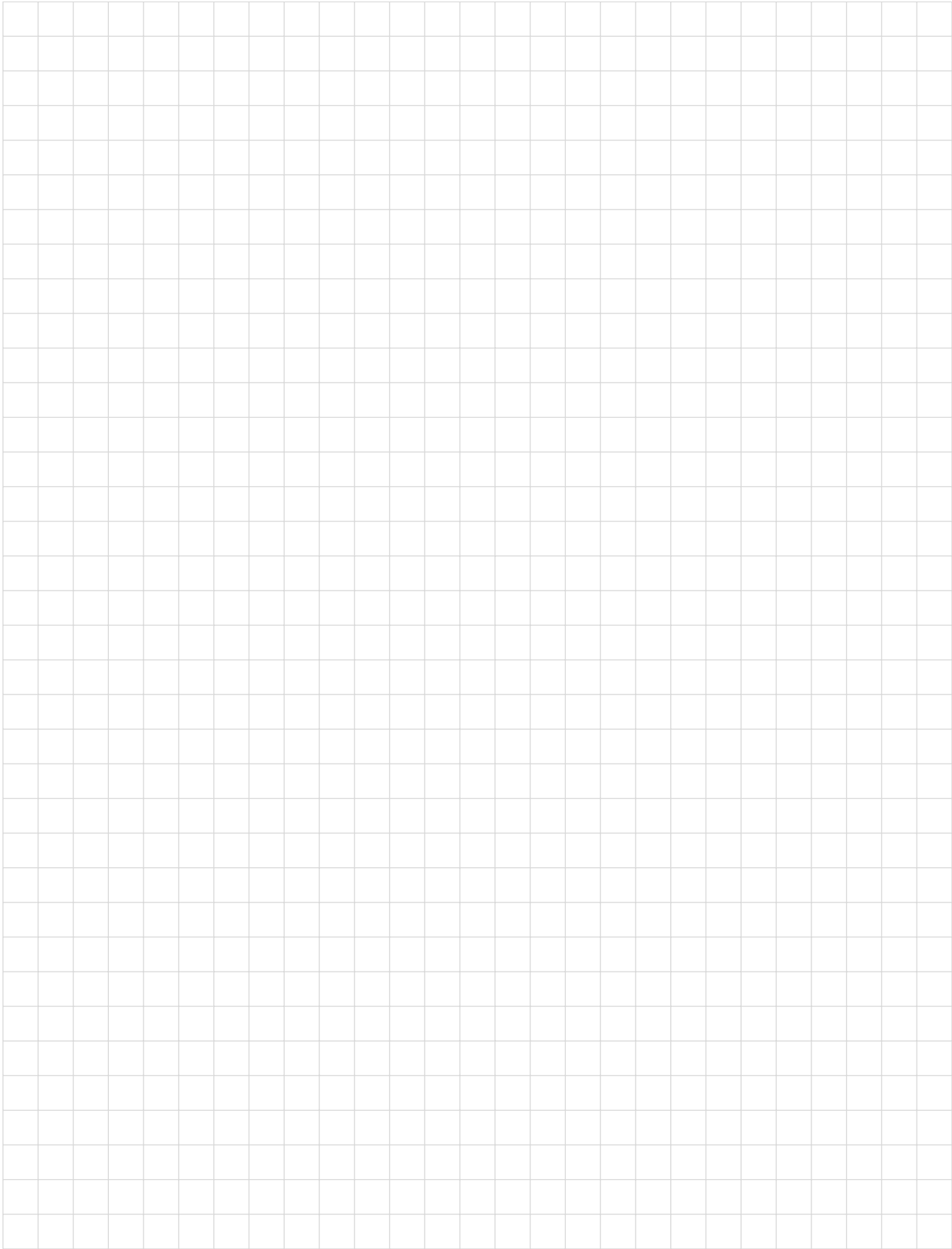
Wash hands thoroughly after handling product.

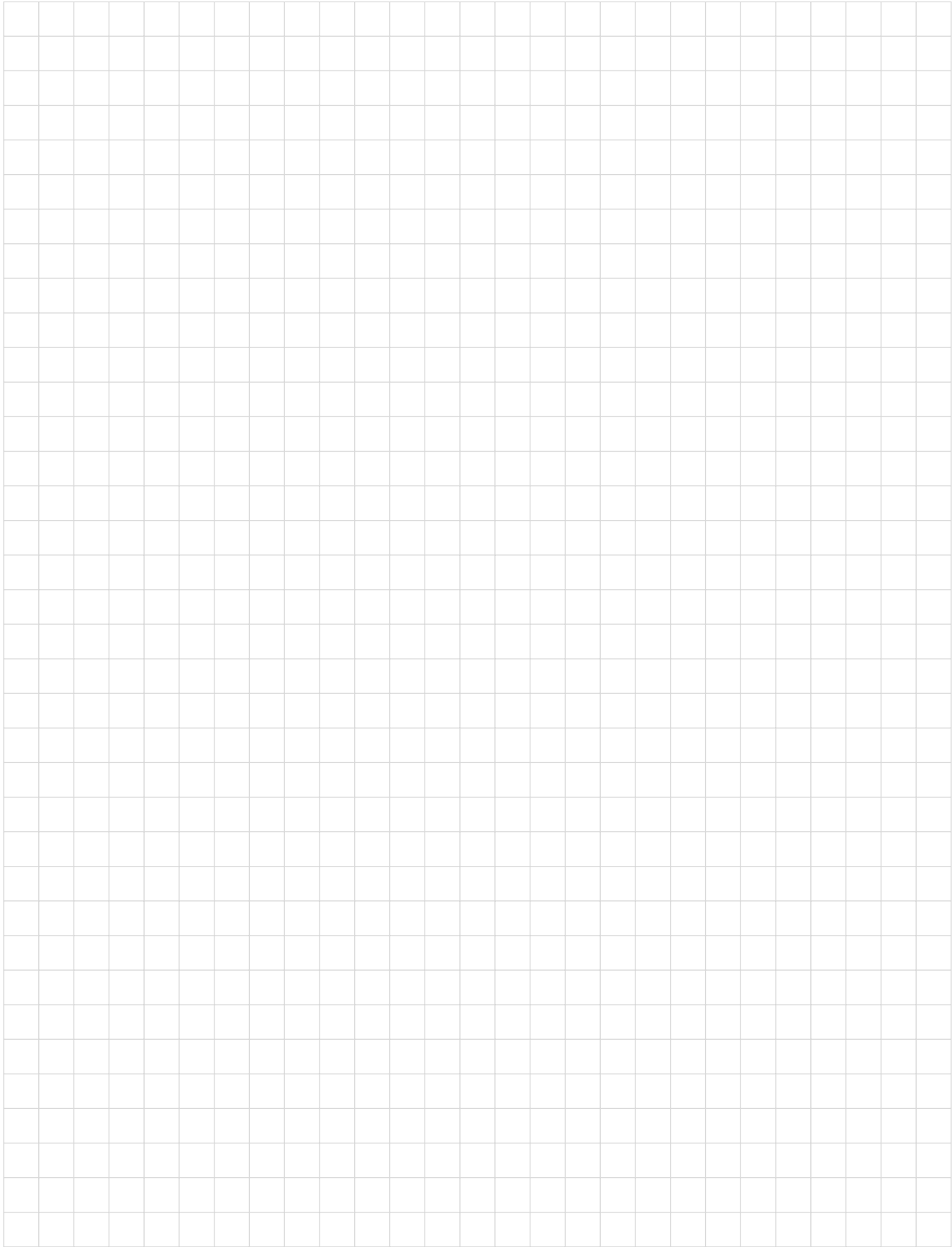
Protect eyes with safety goggles or glasses with side shields.

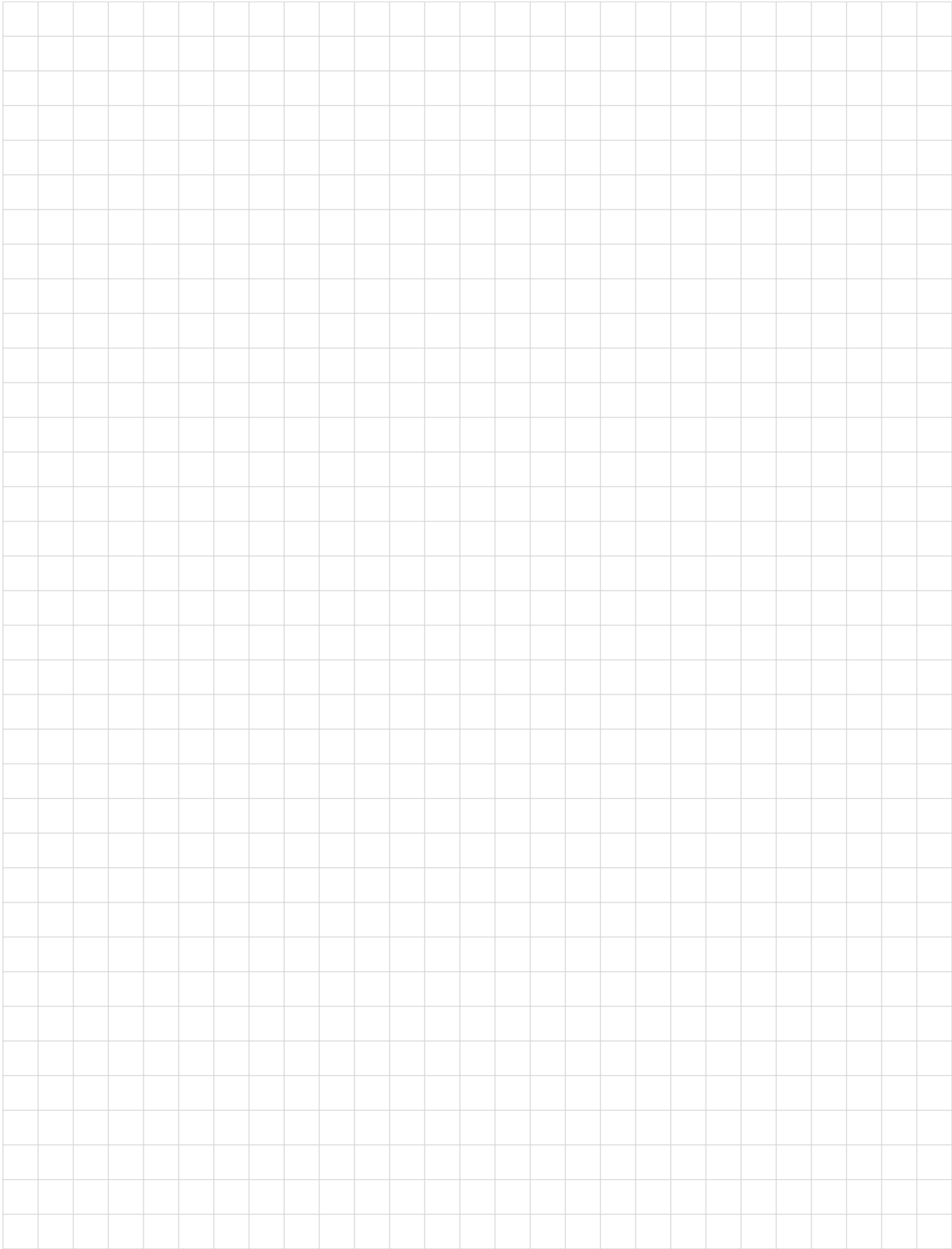
Notes

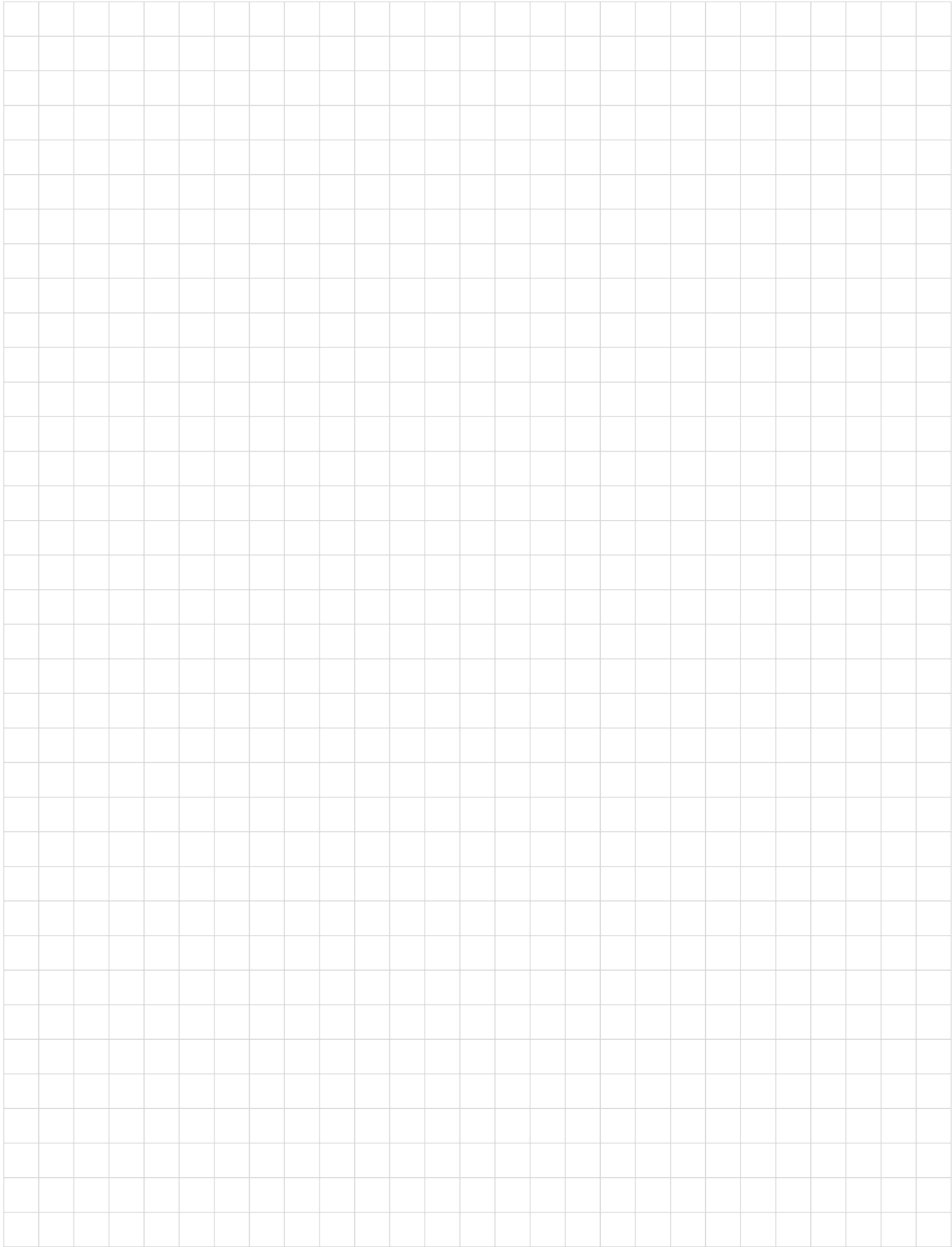












Report Form for Problems and Solutions

We have provided this form to encourage you to tell us about any difficulties you have experienced in using your Spectra-Physics instrument or its manual—problems that did not require a formal call or letter to our service department, but that you feel should be remedied. We are always interested in improving our products and manuals, and we appreciate all suggestions.

Thank you.

From:

Name _____

Company or Institution _____

Department _____

Address _____

Instrument Model Number _____ Serial Number _____

Problem: _____

Suggested Solution(s): _____

Mail To:

Spectra-Physics, Inc.
SSL Quality Manager
1330 Terra Bella Avenue, M/S 15-50
Post Office Box 7013
Mountain View, CA 94039-7013
U.S.A.

E-mail: sales@splasers.com
www.spectra-physics.com

FAX to:

Attention: SSL Quality Manager
(650) 961-7101

